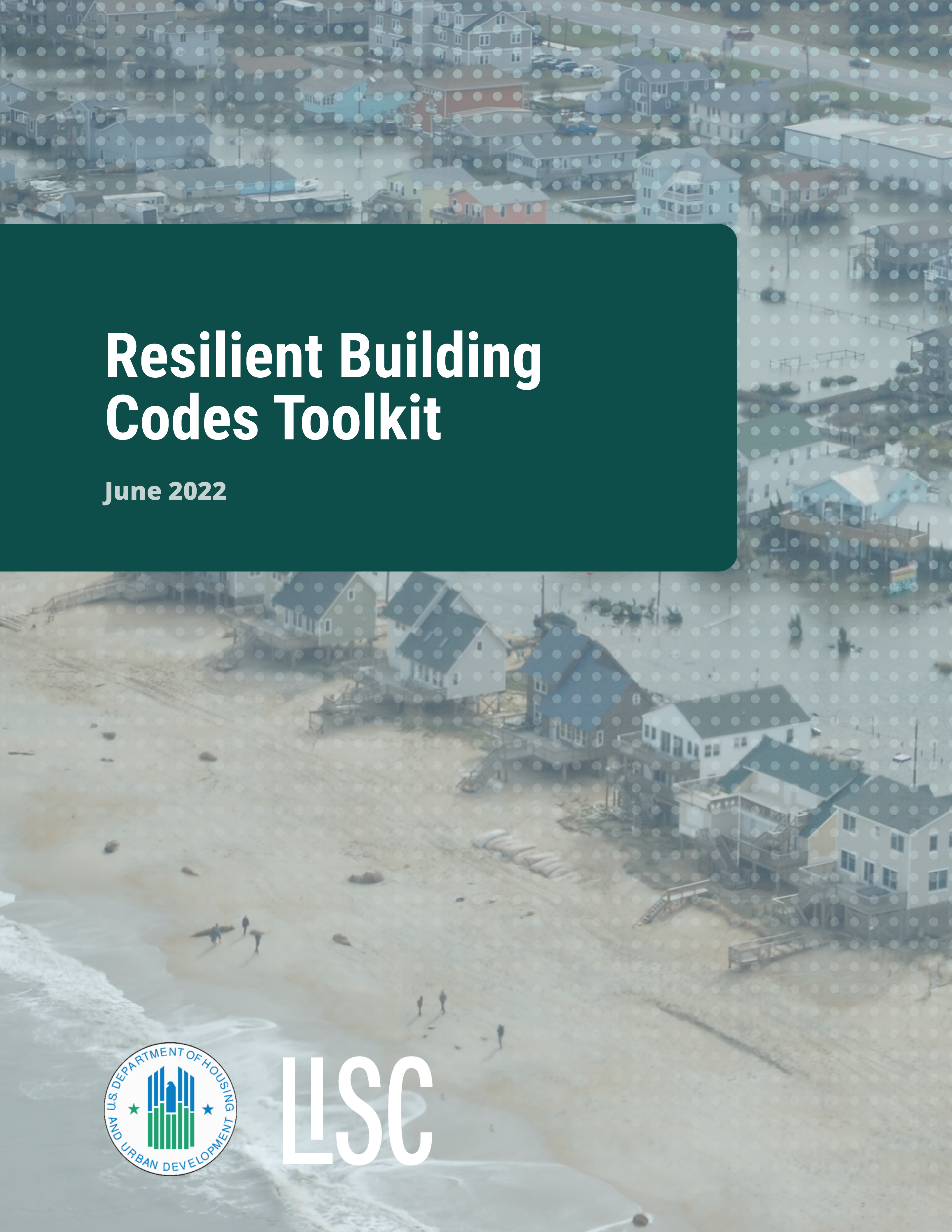

Resilient Building Codes Toolkit

June 2022

WHAT THIS TOOLKIT CONTAINS AND ITS INTENDED AUDIENCE

1

BUSINESS CASE OVERVIEW (4 PAGES)

Gets to the "why" and the relevance

Target audience: *Elected officials*

2

NARRATIVE (~30 PAGES)

Easily searchable document that describes the context of building codes, governance, challenges, and solutions

Target audience: *Practitioners (code officials, architects, engineers, home builders, realtors, contractors, developers, building code committee members, regulators, policy makers)*

3

CHECKLIST (1 PAGE)

How do you learn about building codes in your state?
What can you do to make changes locally?

Target audience: *Communities, municipalities*

4

CODE REQUIREMENTS BY STATE (4 PAGES)

Summary table showing adopted codes, and indicating state mandates as of March 2022

Target audience: *All audiences*

5

STATE-BY-STATE AMENDMENT PROCEDURES (30 PAGES)

Target audience: *Mostly communities and municipalities but anyone interested in how to change the code at a local level*

6

TECHNICAL APPENDIX FOR HAZARD-SPECIFIC INTERVENTIONS (35 PAGES)

Easily searchable document providing a deep, detailed dive on various codes and best practices arranged by hazard

Target audience: *Practitioners*

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EXHIBITS

cover photo NCDOTcommunications flickr.com/photos/ncdot/8142127067

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INTRODUCTION

The intent of this work

Building codes are regulations used to establish minimal life safety requirements for the construction of new buildings and retrofits to existing buildings. They underpin how we design and construct housing and other building types. While ubiquitous, the details of their requirements, governance, and overall application may vary from state to state and, within states, from locality to locality.

While the intent of building codes originally focused on life safety, there has been a shift to think more broadly, incorporating aspects of both sustainability and resilience. The recent increase in the frequency and intensity of extreme weather events has made these concepts even more relevant.

The intent of this guide is to bring transparency and clarity to building codes, especially with respect to resilience. Its target audience includes elected officials and communities seeking to leverage building codes to further enhance their own resilience. The information presented here also has value for practitioners and other industry stakeholders including code officials, architects, engineers, home builders, realtors, contractors, developers, building code committee members, regulators, and policy makers. The main objective of this work is to create a centralized repository and platform that allows the building community to navigate an otherwise challenging environment. Ultimately, the goal is to enhance resilience in the built environment, specifically with respect to housing and other critical building assets.

What are building codes and standards?

Building codes are regulations used to establish minimal life safety requirements for the construction of new buildings and retrofits to existing buildings. They are derived through a negotiated process which involves input from both public and private sector entities. The model codes — those codes that form the basis of state- and community-adopted codes — are updated on a three-year basis. Building standards are the translation of code requirements into more specific design criteria.

The International Building Code (IBC) and the International Residential Code (IRC) are the base model codes used in the U.S. for the housing market. They reference and draw upon other codes and standards. Each jurisdiction is responsible for determining which codes to adopt (if any) and what types of construction these codes will cover. In addition to regulatory standards, there are also voluntary standards, including but not limited to **FORTIFIED Homes** offered by IBHS, which can be used to design more resilient structures, as well as the National Green Building Standard ICC-700 (NGBS, which while part of the ICC suite of I-codes is more typically administered as a voluntary, above-code program. **NGBS Green** certification administered by Home Innovation Research Labs has an option for NGBS Green + Resilience, combining environmental high performance with resilient construction.

Coverage of the IBC and IRC

The IRC provides a complete set of code requirements for one- and two-family detached residences and townhouses three stories or less. The IBC covers all other buildings including multifamily. The IBC references multiple other codes that cover specific building attributes and systems.

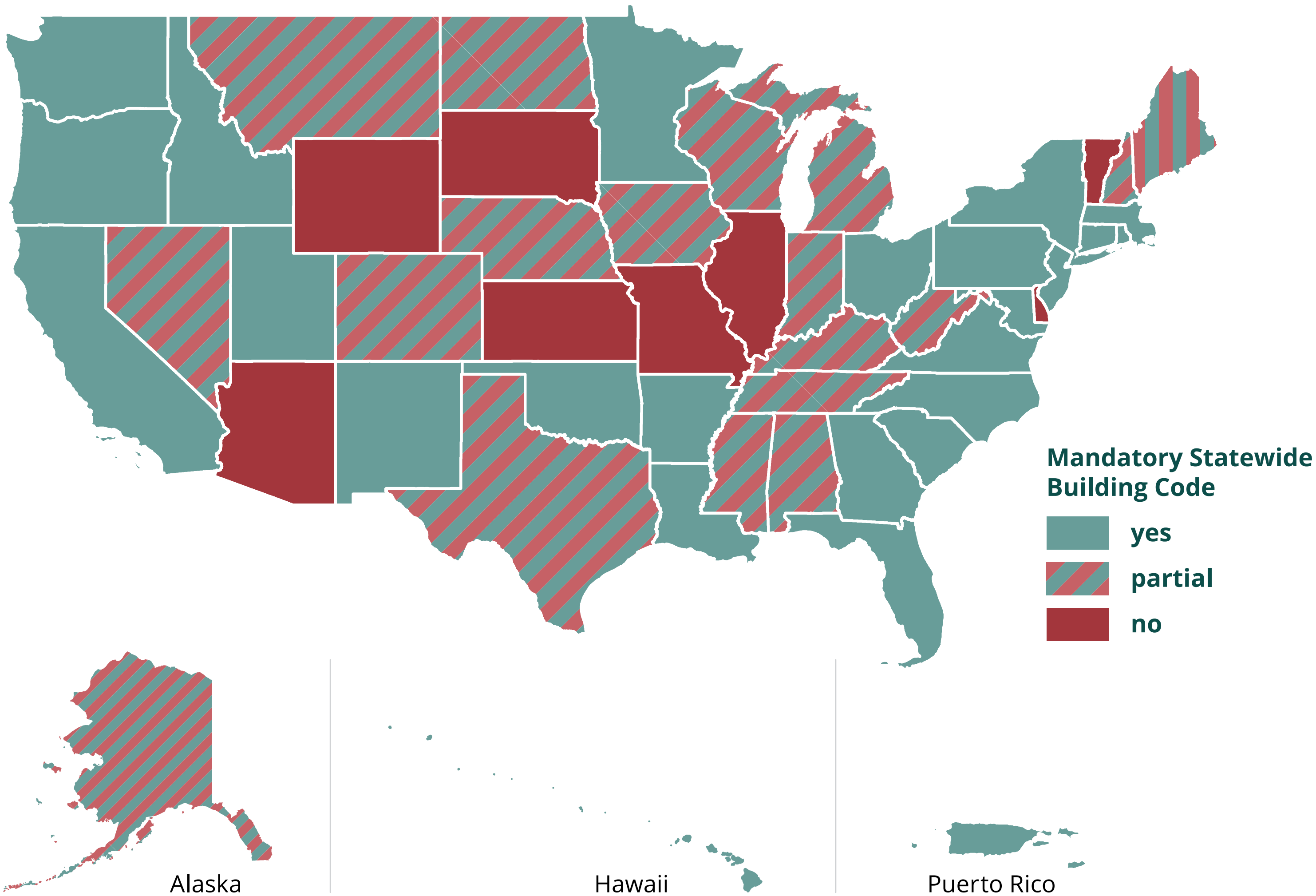
Why focus on building codes?

- Building codes underpin the key health and safety aspects of our built environment.
- They are a combination of operational expectations and physical requirements, with variations in interpretation and applications based on geography and building type.
- They are governed at the state and/or local level but nearly always reference international and national model codes and standards.
- Climate change is a new risk that is not commonly addressed in existing codes and standards.
- Updates to codes can take years because of a need to reach agreement across public and private sectors and within the technical and regulatory arenas.
- The pace of code adoption may not meet the urgency required by climate change.
- This guide provides a roadmap of how municipalities, homeowners and renters, businesses, developers and designers alike can achieve greater resilience within housing within the current system of building codes.
- Three main themes will be explored:
    1. The business case for improved building codes
    2. The governance of building codes
    3. A technical continuum of interventions (minimum code requirements to best-in-class)

- The work will focus on improving resilience in the face of flooding (sea level rise, storm surge and inland flooding), extreme temperatures (heat and cold), wildfires, and wind.
- The guide is written to be accessible by all and supported by more technical and detailed information in appendices.
- The goal of this guide is to provide a view into how codes work, what they currently protect and how they can be leveraged to improve resilience of buildings to climate change.

Exhibit 1 Which states have mandatory statewide building codes?

Yes, partial, and no refer to whether statewide code mandates apply for all building types; some mandates for some building types (partial); or no state-level code requirements. See Appendix A for detailed listing.



See **Appendix A** for a detailed summary of code requirements by state, include what criteria are used to determine "partial."

How building codes differ from land use and zoning ordinances

Land use refers to how land is used and occupied. For example, a lot could be used for housing, open space, farmland, commercial space, or industrial activity. In many jurisdictions, zoning ordinances determine the appropriate uses for that land and establish guidelines for how the land can be developed. These ordinances commonly cover types of uses allowed in particular areas (e.g., commercial versus residential) and the overall size, general dimensions, and density of development.

Building codes focus on the performance of the building itself, often with little reference to the immediate or surrounding land uses (although Wildfire–Urban Interface (WUI) code includes a stated awareness of the need for defensible space directly adjacent to the building).

There is also a difference in governance between the two that varies by state and even across municipalities within each state. While this adds to the complexity, it also provides opportunities for local communities to build more resiliently than what is in the current base code. Since codes (and many standards) are adopted through a multi-year, negotiated process, they can be several years out-of-date by the time they are adopted and may not necessarily represent newer industry practices. This is especially true for climate change influenced designs and construction.

While building code adoption is usually controlled at the state level, zoning practices are almost always controlled at the local level. This lets municipalities integrate more stringent resilience requirements as well as performance-based standards that may exceed the minimal criteria of the formally adopted state building codes.

What is the difference between prescriptive standards and performance-based standards in building codes?

Prescriptive standards require that construction be built according to a prescribed set of measurements and inputs. For example, the first-floor elevation must be located 2 feet above grade. Performance-based standards are based on an expected outcome and allow for creativity in how that outcome is achieved. For example: the building must be designed to allow for continued access and operation during a two-foot flooding event. In this case, there are other options to achieving that goal besides just raising the first-floor elevation by two feet.

CONTENTS

MAKING THE BUSINESS CASE

Building codes are a way to promote minimal life safety standards and, through that, afford a level of protection for the occupants, as well as imparting aspects of durability to the buildings themselves. Recent enhancements to the code, including energy efficiency considerations and the ability to withstand additional hazard types and intensities, have shifted the focus from strictly life safety aspects to broader resilience considerations. A truly resilient building is one that allows occupants to remain safely in place or to return to a safe and functioning environment immediately following an event. It also includes buildings whose overall operations and systems can withstand increasing climate change pressures from both acute shocks and longer-term stressors.

Municipalities depend on a healthy building stock to ensure a viable tax base, which allows local governments to be able to provide critical services. Buildings that deteriorate, are heavily damaged, or become expensive to operate can all lead to devaluation of assets and erosion of the tax base. A reduced tax base could lead to a reduction in city services, difficulty securing adequate capital, and challenges attracting or retaining business and other investments. There are already cited instances where the inability to keep pace with climate changes has impacted local economies and, in extreme cases, led to entire towns being abandoned.[1]

Developers and investors are actively tracking just how prepared cities and towns are for climate change. A recent **report** from the Urban Land Institute proposed a suite of indicators to assess that level of preparedness, many of which have direct application to the resilience of the overall building stock, as well as the supporting infrastructure and municipal services.[2] The work focused primarily on predicting areas prone to climate migration risk.

1 Flavelle, C., 2021. **Climate change is bankrupting America's Small Towns**. *New York Times*, September 15, 2021.

Cusick, D., 2020. **Climate Helped Turn These 5 Places into Ghost Towns**. Scientific American. October 30, 2020.

2 Urban Land Institute. **Climate Migration and Real Estate Investment Decision-Making**. Washington, DC: Urban Land Institute, 2022.

Exhibit 2 **Preliminary market assessment criteria and indicators to assess climate migration risk**

Criteria	Indicators
Economic fundamentals	• Levels of protection offered by existing infrastructure • Area median income; disposable income • GDP sectoral composition • Corporate and/or anchor institution presence • Inequality • Housing affordability
Physical risk exposure	• Exposure of assets and market, including value at risk
Transition risk exposure*	• Assets and primary tenants • Key economic sectors
Market-level adaptive capacity	• Credibility of resilience plans • Fiscal capacity of relevant public-sector agencies • Track record of local institutions addressing resilience

* Includes potential shifts in underwriting practices related to insurance and credit ratings, as well as energy burden considerations.
Table based on ULI's Initial Market Screening tool for climate migration risk.

Other disincentives include changes in the availability and affordability of insurance, potential credit rating downgrades and even the potential for mortgage defaults (discussed in more detail below). However, building codes present an opportunity for a proactive approach, one that can increase the adaptive capacity of the building stock. Enhancing the resilience of the building stock plays an important role in maintaining a vibrant community and healthy business sector. These factors help to stabilize the local economy, which enables a municipality to continue providing critical services. Community-wide resilience can be achieved only if there is sufficient adaptive capacity within the built environment. This is where building codes can play an important role.

The return on investment for resilience

It can be challenging to capture the actual return on investment with respect to resilience. It requires capturing and quantifying avoided losses and costs, thinking across the life expectancy of the asset, and considering both the operational and the physical impacts. The National Institute of Building Sciences (NIBS) **published a study** that quantified the value of resilience in a way that brought greater transparency to its economic value. In short, the study showed a positive return on investment for every hazard and building type — including both new and existing building stock. Just adopting the base code resulted in a $6-10 savings (inland flooding and wind, respectively) for every dollar invested.

National Institute of BUILDING SCIENCES™	ADOPT CODE	ABOVE CODE	BUILDING RETROFIT	LIFELINE RETROFIT	FEDERAL GRANTS
Overall Benefit-Cost Ratio	11:1	4:1	4:1	4:1	6:1
Cost ($ billion)	$1/year	$4/year	$520	$0.6	$27
Benefit ($ billion)	$13/year	$16/year	$2200	$2.5	$160
Riverine Flood	6:1	5:1	6:1	8:1	7:1
Hurricane Surge	not applicable	7:1	not applicable	not applicable	not applicable
Wind	10:1	5:1	6:1	7:1	5:1
Earthquake	12:1	4:1	13:1	3:1	3:1
Wildland-Urban Interface Fire	not applicable	4:1	2:1	not applicable	3:1

Source: National Institute of Building Sciences

FEMA conducted a similar study but with a stronger focus on codes. The focus was on estimating the avoided number of losses by hazard types based on the adoption of model I-Codes. The avoided costs ranged from $484 million to $60 million for flooding and hurricane winds alone.

Exhibit 3 **National findings of modeled I-Code savings**

	NUMBER OF POST-2000 STRUCTURES	MONEY SAVED (ANNUAL AVERAGE)
Flood	786,000	$484 million
Hurricane wind	2.4 million	$60 million
Earthquake	9.2 million	$1.1 billion

Source: Building Codes Save: A Nationwide Study of Loss Prevention, FEMA

Business case aspects at the community level

A non-resilient housing stock can create significant financial stresses for individuals as well as larger economic impacts at the municipal and regional levels. The fiscal health of a municipality is directly dependent on the health of its residents and businesses. Safe, reliable buildings are an essential determinant of the overall health of those two sectors. Climate change has the potential to increase both the frequency and intensity of short-term damages as well as the longer-term degradation of those buildings. In doing so, it can impact both the financial and economic stability of the larger community. The potential for mortgage defaults, loss of and/or an increase in the cost of insurance, credit rating downgrades, climate migration and decreasing disaster relief funding have all been implicated as potential ways in which climate change could fuel a devaluation in property and economic standing at local levels. Below is a brief summary of each of those topics.

Mortgage defaults

The relationship between mortgage defaults and climate change has received significant attention in recent years. Housing is often the largest source of household wealth and a wide-spread devaluation within the housing stock could also lead to significant economic losses at the local level.[3] A recent study looking at post-Harvey recovery efforts noted that payments of mortgages on damaged homes were more likely to become delinquent than those on homes which did not suffer damage[4] and that the greater the damage, especially for those homes without insurance, the greater the likelihood of prolonged delinquency (180 days or more) and eventual default. Another study has estimated that 80% of Houston homeowners who experienced the most damage did not have flood insurance.[5]

There has been growing concern regarding the level of climate risk sitting within the U.S. housing portfolio. A recent study estimated that homes at risk for flooding are overvalued by $34 billion.[6] Another study estimated the "unpriced flood costs" are already at $520 billion today and could reach $643 billion by 2050.[7]

Other indicators of climate pricing have been captured including the observation of sea level rise being priced into house transactions. The impact was estimated to be as much as $3.71 per square foot year on year compared

3 U.S. Commodity Futures Trading Commission, 2020. **Managing Climate Risk in the U.S. Financial System: Report of the Climate-Related Market Risk Subcommittee**, Market Risk Advisory Committee; 196 pages

4 Kousky, C. et al, 2020. **Flood Damage and Mortgage Credit Risk: A Case Study of Hurricane Harvey.** *Journal of Housing Research*, vol. 29, # S1, S86-S120.

5 Long, H., 2017. **Where Harvey is hitting hardest, 80 percent lack flood insurance**. *Washington Post* (August 29, 2017).

6 Hino, M. and Burke, M., 2021. **Does Information about Climate Risk Affect Property Values?**, NBER Working Paper 26807.

7 Evans, D. et al, 2022. **Unpriced costs of flooding: An emerging risk for homeowners and lenders**. Milliman white paper.

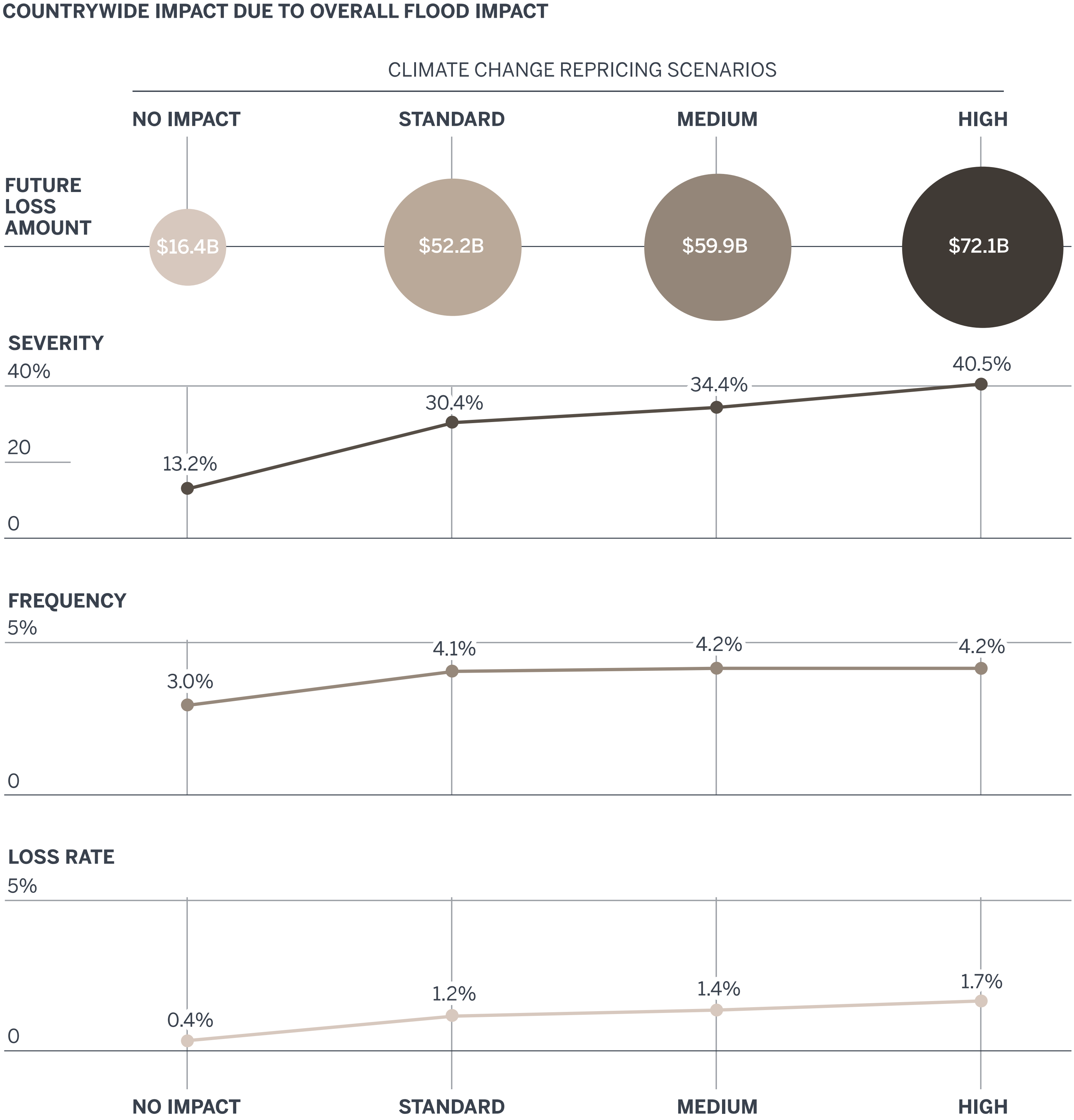
with properties not at risk.[8] Another study noted that homes exposed to sea level rise were selling at a seven percent discount in some areas of Florida, although the discount appeared mostly in second homes, not primary residential homes.[9]

8 McAlpine, S.A., & Porter, J.R., 2018. **Estimating Recent Local Impacts of Sea-Level Rise on Current Real-Estate Losses: A Housing Market Case Study in Miami-Dade, Florida**. *Population Research and Policy Review*, Volume 37, pages 871-895.

9 Bernstein, A., Gustafson, M., & Lewis, R. **Disaster on the horizon: The price effect of sea level rise**, *Journal of Financial Economics*, Volume 134, Issue 2, November 2019, pages 253-272.

Exhibit 4 **Future mortgage loss dollars by scenario**

This figure outlines the potential future mortgage losses (in dollars) based on the following scenario considerations: overall severity of impact, frequency of impact and the rate of loss.



Source: Evans, D.D., et al, 2022. **Unpriced costs of flooding: An emerging risk for homeowners and lenders**.

Insurability considerations

Insurance is often viewed as a key mitigation solution for climate impacts. However, there are important nuances that need to be considered when relying on insurance as a way to hedge against climate risk: **(1)** it has a short-term focus; **(2)** eligible buyers may be unaware of extent of risk; **(3)** the focus of insurance coverage is more on direct physical damage versus operational continuity, and **(4)** an increasing likelihood of inadequate and/or unaffordable coverage as climate change intensifies.

1 SHORT-TERM FOCUS

Insurance offers year to year protection and can be modified, repriced and withdrawn at the end of that year's offering. It is a not a guaranteed option for the life of the asset and the time horizons of its business model (risk is assessed and re-priced on a yearly basis) do not align with the long-term interests of homeowners, communities or local governments.

As an example, insurance prices risks based on the likelihood of an event happening in that particular year. In other words, the underwriting is based on what a one percent chance of flooding (a one-in-a-100 year) event might look like based on historic observations. That risk is reset each year, failing to capture the cumulative risk to a property. If we were to forecast that risk over the life expectancy of a mortgage (30 years) or even further out to 50 years, the cumulative risk of flooding would actually be 26 percent or 39 percent, respectively. To state it another way, there is a 26 percent chance that the property would be flooded at least once during those 30 years. That is a much more relevant statistic to a homeowner than the year-to-year calculation. By understating the hazard, we understate the risk and thereby underestimate the value of resilient interventions, such as more resilient building codes.

2 ELIGIBLE HOMEOWNERS UNAWARE OF EXTENT OF RISK

FEMA has **mapped** the extent of potential flood risk based on historic data and with respect to annual occurrence. These maps are used to determine which mortgaged properties are required to have flood insurance. These areas are referred to as special flood hazard areas (SFHA). Flooding may occur outside of these zones but since mortgage institutions do not require homeowners to carry insurance for those areas, most people are often unaware of that risk. It has been estimated that at least 5.9 million properties sit outside of the SFHA but still face a significant risk of flooding.[10] Similar challenges have been noted with wildfire risk where it has been noted that most homebuyers are unaware of the actual risks when purchasing their home.[11]

In addition to understanding the current risk, there are also challenges in understanding how that risk may be shifting. For example, a recent report projects that sea level elevations are expected to rise an average of eight to ten inches over the next thirty years (2020-2050 timeframe) along US shores.[12] Similar shifts have been projected for wildfire, drought, temperature, and precipitation,[13] as well as the severity of storm events.[14] Housing stock once located in relatively "safe" areas may have already become more exposed and less resilient with projected shifts in climate change.

3 FOCUS ON PHYSICAL IMPACTS, NOT OPERATIONAL CONTINUITY

Designing to a more resilient standard means that the overall physical damage and interruption of services to a particular building will be less severe in the midst of both short-term and longer-term disruptions. Focusing on resilience requires that the design incorporates more than just life safety considerations (e.g., ensuring people can evacuate safely without being injured by a failing building). It requires designers and contractors to develop and construct a "hardier" structure — one that is able to withstand greater impacts and remain operational during the event as well as continuous occupancy during or directly after an event. The main function of a home — whether a single or multi-family residence — is to ensure a healthy and safe place to live. A truly resilient home is one that provides for that environment during and directly after a major event.

Studies have shown that these impacts are even greater for vulnerable populations (including people of color, low income and the elderly) Recent work by the EPA showed a higher risk within vulnerable pop-

10 First Street Foundation, 2020. **First National Flood Risk Assessment**.

11 Champp. P.A. et al, 2010. **Homebuyers and Wildfire Risk: A Colorado Springs Case Study**, *Society and Natural Resources*, Volume 23; pages 58-70.

12 Sweet, W.V. et al, 2022: **Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines**. NOAA Technical Report NOS 01. National Oceanic and Atmospheric Administration, National Ocean Service, Silver Spring, MD, 111 pages.

13 Climate Toolbox: **Future Climate Dashboard**. Created by University of California Merced.

14 Pidcock, R. et al, 2021. **Attributing extreme weather to climate change**. Carbon Brief white paper.

ulations for both flooding and extreme temperatures than what was reported for reference populations.[15]

Some of the greatest impacts to individuals and communities are tied to the inability to resume what were once daily activities. These include loss time from work, the inability to attend school, maintain employment, often brought about from both short-term or longer-term impacts of being temporarily dislocated or permanently relocated after these events. Several studies of school disruptions following major events have illustrated the significant negative academic and mental health impacts that leave long-lasting impacts on the students.[16] Since schools often provide additional social services to people in need, those impacts often extend to the students' families as well. Schools should be treated as critical assets to aid in both the sheltering and recovery aspects of extreme events. Resilient building codes would go far in providing that continuity of service.

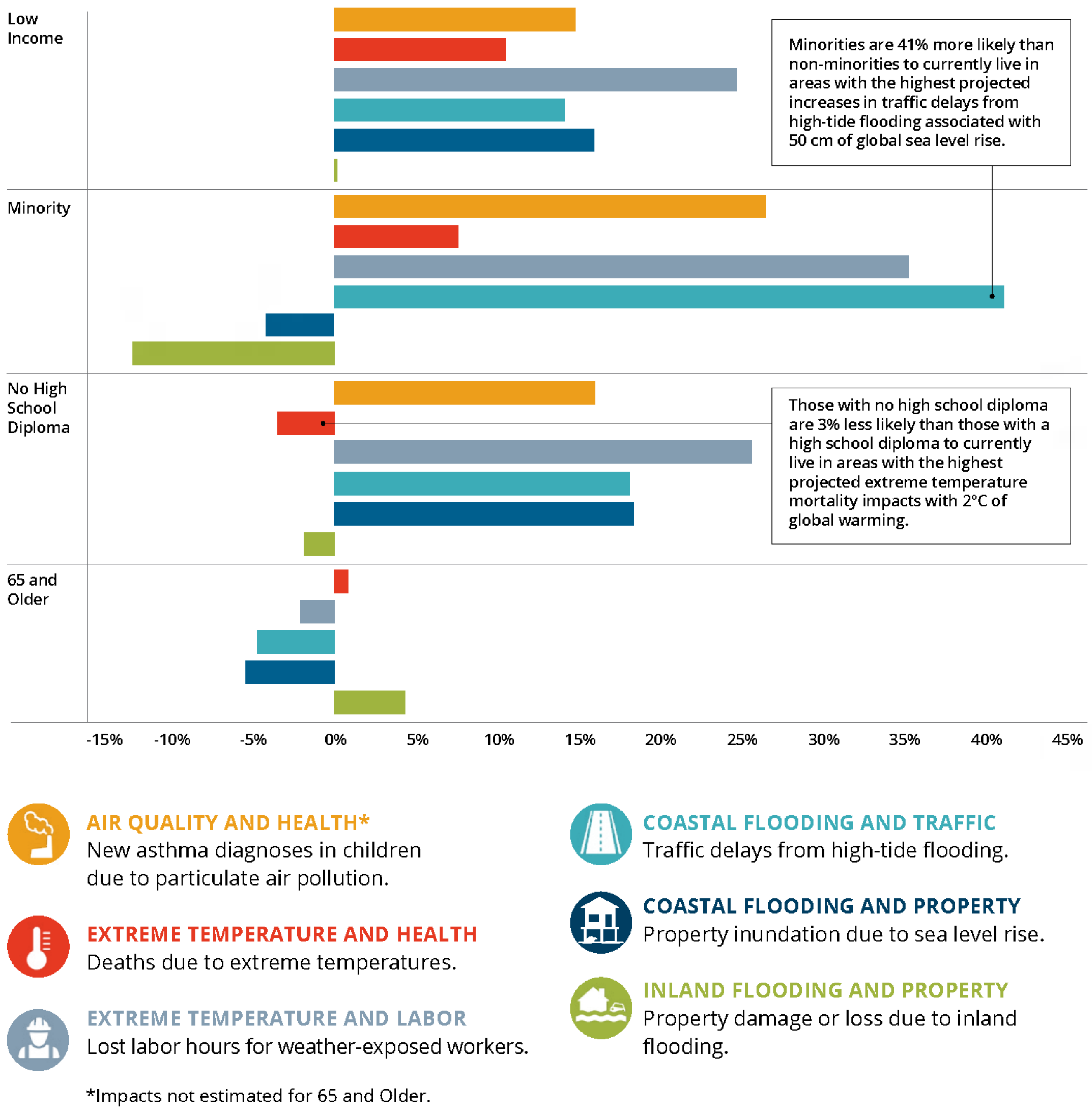
16 Dolch, N.A. et al., 2008. **Hurricane Disaster Response by School-Based Health Centers**. *Children, Youth and Environments* Volume 18(1), pages 422-434.

Segarra-Almestica, E. V. et al., 2021. **The Effect of School Services Disruptions on Educational Outcomes after Consecutive Disasters in Puerto Rico**. Natural Hazards Center Public Health Report Series, 2. Boulder, CO: Natural Hazards Center, University of Colorado Boulder.

Goldstein, D., 2017. **School Closings from Harvey Threaten Disruption Across Texas**. *The New York Times*, August 29, 2017.

Exhibit 5 **Differences in risks to socially vulnerable groups relative to reference populations with 2°C of global warming or 50 cm of global sea level rise**

The estimated risks for each socially vulnerable group are relative to each group's "reference" population, defined as all individuals other than those in the group being analyzed. The estimated risks presented in the chart are for scenarios with 2°C of global warming (relative to the 1986-2005 average) or 50 cm of global sea level rise (relative to 2000). For the inland flooding analysis, the baseline is 2001-2020.



Source: EPA, 2021. **Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts**. U.S. Environmental Protection Agency, EPA 430-R-21-003.

Even if the weaknesses of the NFIP are repaired, insurance alone may not be enough to sustain the complex system of risk allocation that underlies the housing system. The magnitude and persistence of climate change, particularly in the latter part of the 21st century may overwhelm the ability of insurance to spread and manage risk.

Source: Becketti, S. 2021. The Impact of Climate Change on Housing and Housing Finance. Research Institute for Housing America Special Report, in collaboration with the Mortgage Bankers Association, 41 pages.

4 INADEQUATE AND/OR UNAFFORDABLE COVERAGE

The National Flood Insurance Program (NFIP) is federally-backed and funded, and requires that flood insurance be offered to any home identified with the current special hazard flood areas (SHFA). These areas are based on historic climate data and do not account for climate change. The program is currently $20 billion in debt even before taking additional climate burdens into account.[17]

First Street Foundation conducted a study which looked at the disconnect between insurance coverage and actual costs incurred from flooding and found that more than 4 million homes would face losses equal to 4.5 times the cost of the estimated NFIP premiums.[18] The cumulative average annual loss (AAL) for residential properties alone was estimated to be $20 billion this year with an expected loss of more than 32 billion in 30 years, directly attributable to climate change impacts.[19]

In recent testimony to the United States Senate Special Committee on the Climate Crisis, David Burt of DeltaTerra Capital stated that insufficient funds are being collected by insurers to cover the risk of climate risk. Specifically, “annual damages to residential real estate will be roughly 0.85 percent per year, 58 percent higher than the amount collected by insurers to cover it. The disconnect is larger in high-risk places like Florida, where risQ[20] predicts residential losses that are 87 percent higher than the insurance premiums collected there, despite those premiums being the highest in the country.”[21]

His testimony continues, stating that “in 2007, investors made the irrational assumption that real estate demand would keep increasing indefinitely as more mortgages were given to less and less qualified borrowers. This kept inflating home values until it became obvious to all that many of these borrowers had no real hope of paying off their mortgages once their income potential was accurately considered. Today, investors are making an equally irrational assumption that the cost of ownership will stay constant even as catastrophe costs increase. This is flawed reasoning and ultimately insurance premiums, taxes, and uninsured losses will increase in risky regions.”

17 Congressional Research Service, 2021. **A Brief Introduction to the National Flood Insurance Program**.

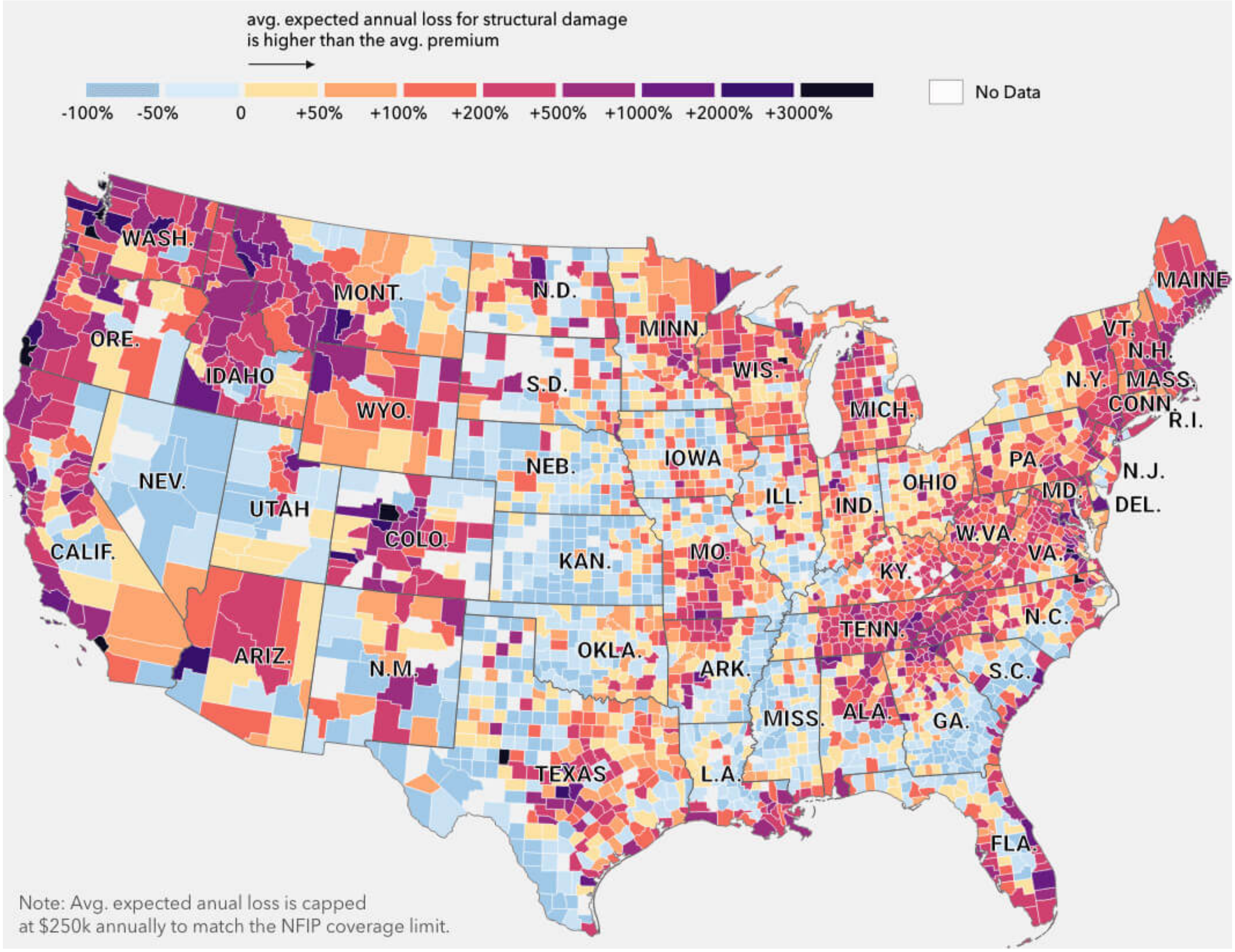
18 First Street Foundation, 2021. **Over 4 Million Homes Face Annual Financial Losses 4.5 Times the Cost of Their Estimated NFIP Premiums**. Press Release, February 22, 2021.

19 Ibid.

20 risQ is a climate data analytics company.

21 **Special Committee on the Climate Crisis Hearing: The Economic Risks of Climate Change**, Thursday, March 12, 2020.

Exhibit 6 NFIP insurance premiums compared to economic risk for residential properties with substantial flood risk, 2021



Source: **Over 4 Million Homes Face Annual Financial Losses 4.5 Times the Cost of Their Estimated NFIP Premiums**. February 22, 2021. First Street Foundation.

Governor Raskin of the Federal Reserve also testified that “banks and other lenders and investors are exposed to losses in their collateral or the assets underlying their investments, an exposure that is not understood by bank regulators and is not measured through current examination practices. This material omission may be more troublesome than the failure to appreciate the nature and scope of the risk inherent in derivative banking products in 2008…”[22]

22 Ibid.

She referenced a study outlining how the insurance industry was recalculating its underwriting practices to account for these foreseeable changes and warned that "[a]nother financial cost that will likely be borne by households is the cost associated with more expensive and/or more curtailed insurance policies."[23]

Frédéric Samama, Head of Responsible Investment, Amundi, and co-author of "Green Swan: Central Banking and Financial Stability in the Age of Climate Change" referenced a MunichRe study reporting that "insurance companies cover only 44 percent of the damages in the US (and 8 percent in Asia)" and that "households and banks are increasingly exposed."[24]

Private insurance companies have the option to leave markets where the probability of a disaster is greater than the risk tolerance of their business models.[25] The remaining companies may modify their coverage criteria to include higher prices, or more restricted eligibility criteria. In some cases, when private insurers completely exit a particular market, the state creates its own underwriting entity (e.g., California for wildfire risk and North Carolina for wind) to cover those risks.[26] This means that all residents of the state cover the risk of the most vulnerable properties. As a risk becomes more prevalent, the cost and availability of coverage will also become more challenging.

Other options are being explored, including a push for all-hazard insurance products[27] and long-term insurance products that incentivize investments in resilience,[28] but both are still under development.

Credit rating implications

A municipality's or company's credit ratings are tied to their ability to repay debt. Acute and chronic climate impacts could impact a municipality's fiscal health, and there have been instances where credit rating agencies have

23 Bradley Hope and Nicole Friedman, **Climate Change is Forcing the Insurance Industry to Recalculate**. *Wall Street Journal* (Oct. 2, 2018) (last visited March 2, 2020).

24 MunichRe, 2018. **The Natural Disasters of 2018 in Figures**.

25 Born, P. & Viscusi, W.K., 2006, **The catastrophic effects of natural disasters on insurance markets**. *Springer Science & Business Media*.

26 Hartwig, R.P. and C. Wilkinson, 2016. **Residual Market Property Plans: From Markets of Last Resort to Markets of First Choice**. Insurance Information Institute, 48 pages.

27 Kousky, C., Kunreuther, H. Wachter, S. and LaCour-Little, M. **Flood Risk and the U.S. Housing Market**.

28 See: **Climate Insurance Linked Resilient Infrastructure Finance working group**.

temporarily downgraded credit worthiness based on extreme events (e.g., following Hurricane Harvey, Standard and Poors readjusted its assessment of five utility districts in Texas and Moody's downgraded obligation bonds in Puerto Rico following Hurricane Maria).[29] A reduction in business and tax receipts can affect the cost of borrowing due to the more limited ability to service the obligations associated with the loans. Like insurance underwriting practices, credit rating agencies assess the ability to pay back on a yearly basis. However, some investors are using the climate impact data at a city level to determine whether to shorten their investments to a 10-year rather than a 30-year period as a hedge against climate change.[30]

When buildings are destroyed or damaged during an event, many homeowners and businesses choose not to rebuild or cannot afford to rebuild. This can result in significant reductions in the tax base. As an example, of the 14,000 homes in Paradise, CA, as of November of 2021 less than 1,100 of the homes have been rebuilt. It is estimated the number of homes will be under 10,000 until after 2045. The drop in population associated with the fire has devastated businesses where the reduction in customers has exceeded 50 percent.[31]

29 Kelly, S. 2017 **U.S. municipal disaster plans seen more vital for ratings: report**. Reuters, October 17, 2017.

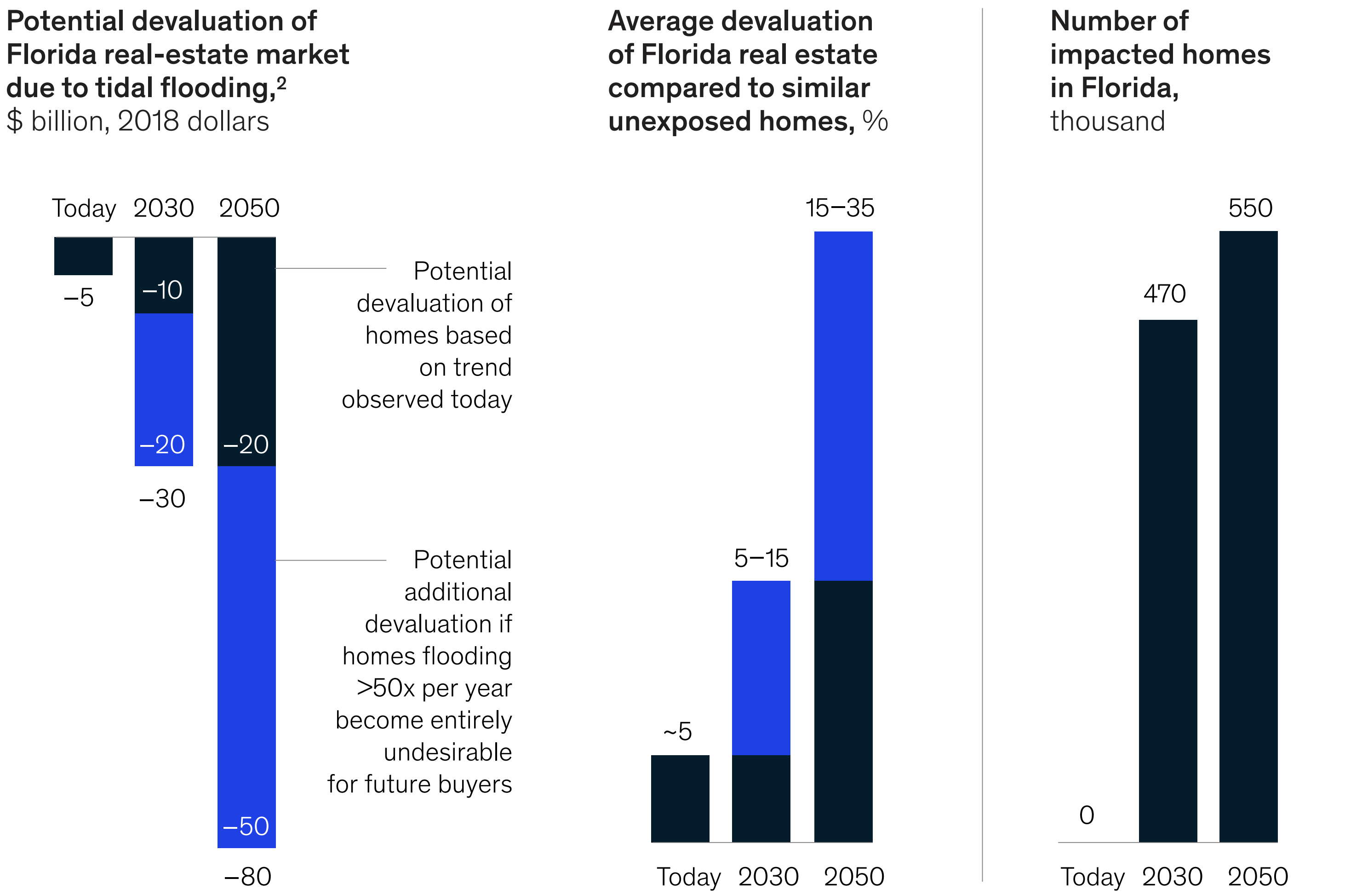
30 Whieldon, E. & Charbonneau, M. 2019, "**Climate change poses new threat to US cities' long-term creditworthiness**," S&P Global.

31 Blevins, J et al. 2021. **On the rise — three years after the fire, the rebuild continues | Camp Fire**, *Chico Enterprise-Record*, November 8, 2021.

Devaluation of property can significantly impact local economies that are heavily depending on the real estate market. Exhibit 7 illustrates the potential devaluation of properties in Florida due to tidal flooding.[32]

Exhibit 7 **Tidal flooding has caused an estimated $5 billion devaluation in real estate, which could grow to between $30 billion and $80 billion by 2050**

Florida real-estate market changes due to tidal flooding, based on USACE[1] high scenario



Note: Sea-level rise based on USACE high curve. High curve results in 1.5 meter eustatic sea-level rise by 2100 (within range of representative concentration pathway 8.5 scenario; see, for example, Jevrejeva et al., 2014). Based on current exposure. See Technical Appendix of the full report for why this climate scenario was chosen. Dollar figures rounded to nearest 5, % figures rounded to nearest 5%.

[1] US Army Corps of Engineers.

[2] Based on First Street Foundation's property-level analysis of relationship between real-estate trends and local experience of tidal-flooding events. Analysis identifies differential appreciation rates for properties that experience tidal flooding in comparison to those that do not, with the former seeing a slower rate of appreciation over study period (2005–17). Analysis relies on assumption that future relationship between flooding impact and home value devaluation equals historical relationship. Low end of range based on historical devaluation; high end assumes homes flooded >50x per year see 100% devaluation.

Source: First Street Foundation, 2019; McKinsey Global Institute analysis

Source: Woetzel et al, 2020. **Will mortgages and markets stay afloat in Florida?** McKinsey Global Institute. Climate risk and response: Physical hazards and socioeconomic impacts — Case Study.

32 Woetzel et al, 2020. **Will mortgages and markets stay afloat in Florida?** McKinsey Global Institute. Climate risk and response: Physical hazards and socioeconomic impacts — Case Study.

Climate migration

People may be forced to leave areas because of the effects of a warming climate. Some of those departures may be related to a single event (e.g., the outmigration following Katrina), others may occur more slowly in response to a variety of stressors (e.g., recurrent events, loss of jobs, reduction in tax base, etc.). Small towns are particularly vulnerable to these shifts[33] and some towns have already become ghost towns because of these climate shifts.[34] There is also a growing awareness of the impacts to the housing market itself (see discussion above) as well as the potential for disappearing local tax bases as a result of climate migration.[35]

Climate impacts can be even more challenging for under-resourced communities that are often dealing with limited resources, economic shortfalls, and an eroding tax base, particularly following disasters.

This lack of capacity at the local level compounds the ability to develop strategies and pursue funding to prepare for climate change. Rural communities face particular challenges. Of the 5,511 communities defined as having very limited capacity (the lowest ranked 25 percent of communities in the U.S.):

- 1,306 (24 percent) have high flood risk,
- 1,518 (28 percent) have high wildfire risk, and
- 446 (8 percent) have both high flood risk and high wildfire risk.[36]

"Repeated shocks from hurricanes, fires and floods are pushing some rural communities, already struggling economically, to the brink of financial collapse."[37] The lack of capacity to pre-position for climate preparedness investments, including building and/or retrofitting structures to be more climate resilient, could result in devaluation at both the individual and community level. **The Rural Capacity Index** highlights these most vulnerable communities and should be used as a way to prioritize where building code improvements (including associated funding) may be needed most.

33 Hersher, R., 2019. **Small Towns Fear They Are Unprepared for Future Climate-Driven Flooding**. NPR. July 25, 2019.

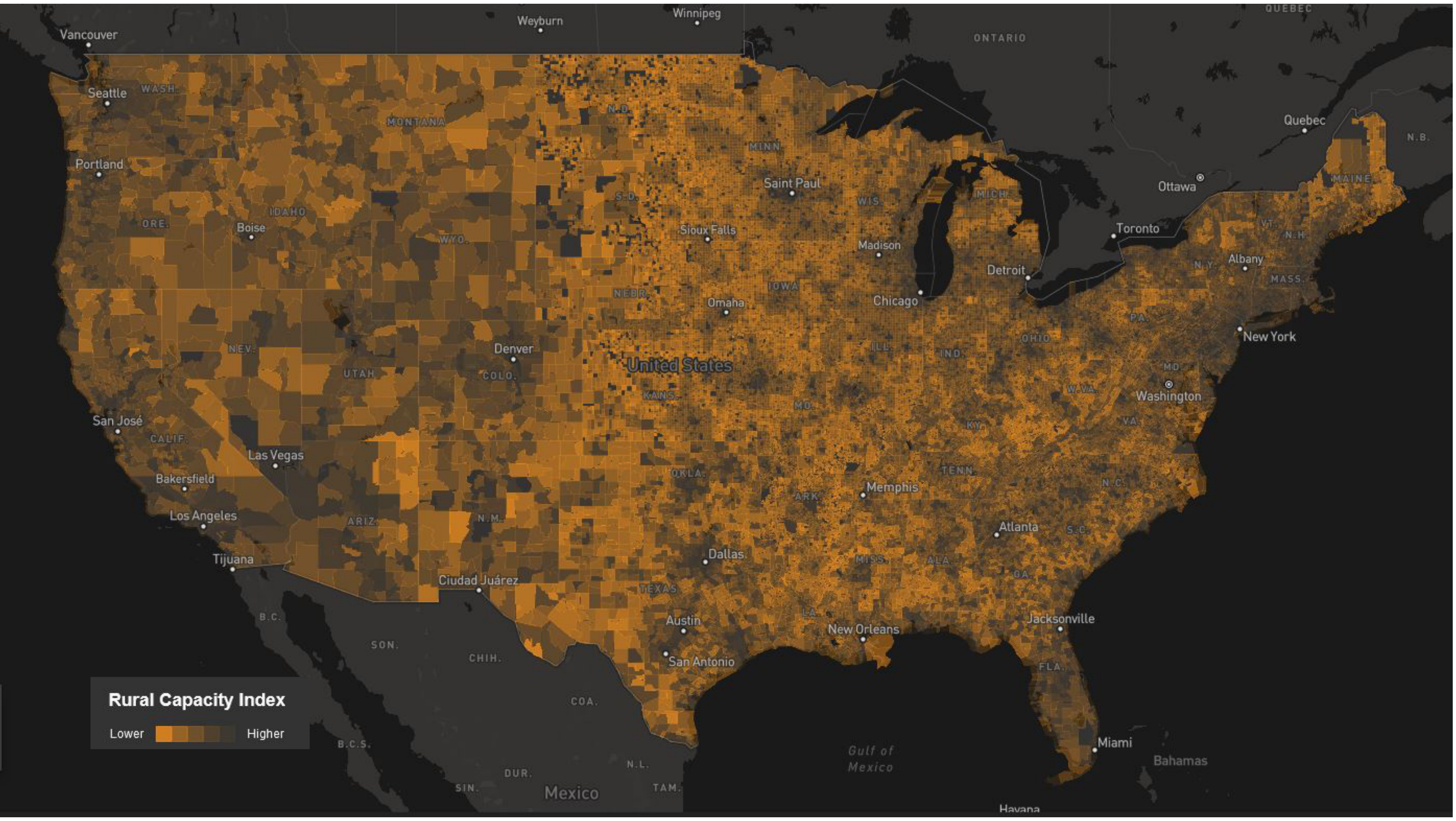
34 Cusick, D., 2020. **Climate Helped Turn These 5 Places into Ghost Towns**. *Scientific American.* October 30, 2020.

35 Marandi, A. and K. L. Main, 2021. "Vulnerable City, recipient city or climate destination? Towards a typology of domestic climate migration impacts in US Cities." *Journal of Environmental Studies and Sciences,* August 2021, pages 1-16.

36 Headwater Economics, 2022. **Rural Capacity Index**.

37 Flavelle, C., 2021. **Climate change is bankrupting America's Small Towns**. *New York Times,* September 15, 2021.

Exhibit 8 Rural Capacity Index



Source: Headwater Economics, 2022. Rural Capacity Index.

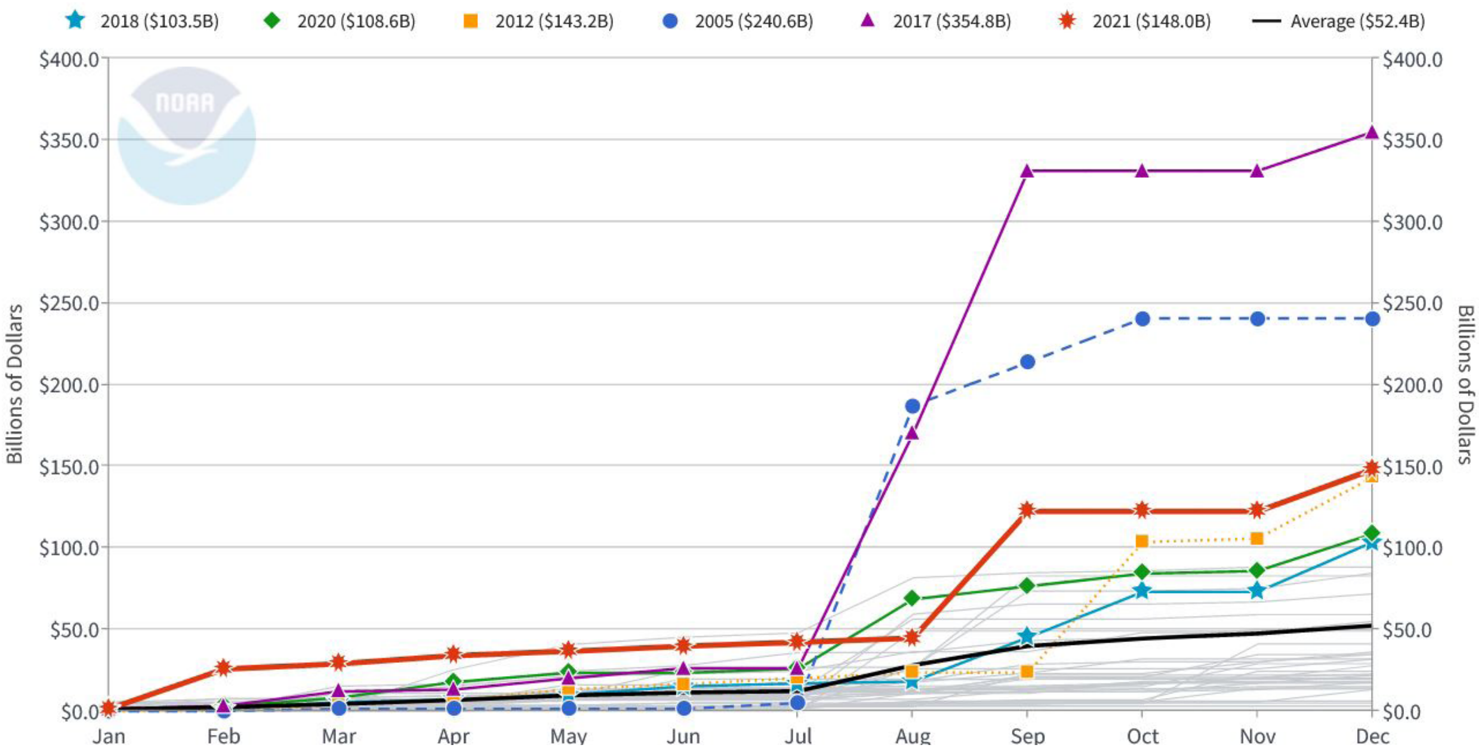
The table below shows, by region, communities, county subdivisions, and counties with Index scores below the national median:

	Communities with low capacity	County subdivisions with low capacity	Counties with low capacity
Midwest	75% (3,245)	76% (7,531)	65% (463)
Gulf Coast	59% (1,860)	58% (1,471)	61% (324)
West	53% (893)	41% (414)	52% (146)
Southeast	51% (1,425)	47% (1,905)	48% (337)
Great Lakes	43% (1,982)	44% (4,584)	41% (214)
Pacific Coast	36% (766)	20% (182)	31% (49)
Northeast	22% (807)	22% (1,352)	13% (33)

Disaster funding availability

Since 1980, 310 natural disaster events have occurred in the U.S., costing more than $2.155 trillion.[38] From 1980 to 2021, the average number of billion-dollar events was 7.4 per year. The average number of events in the last five years (2017-2021) is 17.2 events.[39]

Exhibit 9 1980-2021 U.S. billion-dollar disaster event cost (CPI-adjusted)



Source: NOAA National Centers for Environmental Information (NCEI) **U.S. Billion-Dollar Weather and Climate Disasters** (2022).:

As the quantity of disasters increase due to a warming climate, those funds will need to be either increased or spread over more events. Increases are subject to the political climate at the time and may not be forthcoming when needed. It cannot be assumed there is an unlimited amount of funds available to address the probable increase in climate related events. The availability of disaster funding and the amount can have a considerable effect on the ability of a community to recover from disaster.

38 NOAA National Centers for Environmental Information (NCEI), 2022. **U.S. Billion-Dollar Weather and Climate Disasters**.

39 Ibid.

CONTENTS

HAZARD-SPECIFIC BUSINESS CASE CONSIDERATIONS

The previous section outlined general trends of how climate change impacts to the built environment could impact financial and economic considerations at a local level. The following section introduces hazard-specific building codes and standards that can be leveraged to make buildings more resilient. A more detailed and technical treatment of hazard-specific interventions can be found in **Appendix C**.

Wind

FORTIFIED Wind standards require roofs to be structurally tied to the building in ways that minimize their likelihood of being lifted off and damaged during significant wind events. Taken post-Hurricane Sally in Alabama, Exhibit 10 illustrates the difference in resilience between the FORTIFIED roof and traditional builds. At that time, Alabama had 16,000 IBHS FORTIFIED roofs, all of which withstood the winds of Hurricane Sally. Some roofs experienced shingle loss but remained intact and waterproof.

Exhibit 10 FORTIFIED Home

Source: "**Alabama's nation-leading 16,000 Fortified roofs held up well to Hurricane Sally**." September 27, 2020.

Flood

Hurricane Michael struck Florida as a Category 5 hurricane, resulting in significant flood and wind damage to existing buildings. While FEMA has designated certain areas as Special Flood Hazard Areas (SFHA) based on their likelihood of flooding, the flooding associated with Hurricane Michael extended beyond those zones and inundated areas that had a much lower level of flooding probability — some less than 0.2 percent of annual flooding (Zone X).

The buildings in Exhibit 11 are located outside of the SFHA, but all experienced significant flooding during Hurricane Michael. Since the buildings' main floors were elevated on pilings the building remained structurally intact and overall water damage to the structures was less severe than that experienced by on-slab structures.

Exhibit 11 Representative adjacent single-family dwellings elevated on concrete piles that survived the hurricane (Mexico Beach; unshaded Zone X)

Source: FEMA, 2020. **Mitigation Assess Team Report. Hurricane Michael in Florida: Building Performance Observations, Recommendations, and Technical Guidance**. February 2020.

Wildfire

A recent study of housing stock in California revealed a significant correlation between the adoption of new wildfire building standards and the likelihood that a home would be able to withstand a wildfire event.[40] It also highlighted the fact that the resistance of the more resilient home would also influence the resilience of neighboring homes since the more fire resistant home could act as a "break" of sorts with respect to the wildfire spread.

"We find remarkable vintage effects for California homes subject to the state's wildfire standards. A 2008 or newer home is about 16 percentage points (40 percent) less likely to be destroyed than a 1990 home experiencing an identical wildfire exposure. There is strong evidence that these effects are due to state and local building code changes - first after the deadly 1991 Oakland Firestorm, and again with the strengthening of wildfire codes in 2008. The observed vintage effects are highly nonlinear, appearing immediately for homes built after building code changes. There are no similar effects in areas of California not subject to these codes or in other states that lack wildfire codes.

"We also find that code-induced mitigation benefits neighboring homes, consistent with reduced structure-to-structure spread. These neighbor effects are in keeping with anecdotal reports of home-to-home spread as a factor in urban conflagrations (Cohen 2000; Cohen and Stratton 2008; Cohen 2010). Our results imply that, all else equal, code-induced mitigation by a neighbor located less than 10 meters away (within the distance fire experts refer to as the home ignition zone) reduces a home's likelihood of destruction during a wildfire by about 2.5 percentage points (6 percent). This benefit is even larger when homes have multiple close neighbors."[41]

"We are also aware of at least one insurance company which will not sell homeowners insurance to homes located next to a home with a wood roof in high-risk areas (Allstate Indemnity Company 2018)"

Source: Baylis and Boomhower, 2021. **Mandated vs. Voluntary Adaptation to Natural Disasters: The Case of US Wildfires**.

40 Baylis and Boomhower, 2021. **Mandated vs. Voluntary Adaptation to Natural Disasters: The Case of US Wildfires**.

41 Ibid.

Exhibit 12 House in Elkorn, Oregon
Representative example of fire-hardened home that survived the Beachie Creek Fire in Oregon. The home was built with concrete siding, a cement porch, metal roof with no gutter and air vents and vegetation had been cleared nearby the home.

Source: NPR, 2021. **Oregon has a new plan to protect homes from wildfire. Homeowners are pushing back**.

Extreme temperatures

Extreme temperatures can impact the building stock in different ways. The level of insulation, the ability to ventilate, the capacity and sizing of heating and cooling units, even the color of the roof and location relative to adjacent buildings and/or vegetation all affect a building's performance. National climate maps, based on historic averages, are used to determine how the building should be designed, including the supporting electrical and mechanical systems for these heating and cooling loads. The design of these buildings reflects historical averages and rarely accounts for extreme temperature events, let alone the projected shifts associated with climate change. This means that as the building ages, the average weather patterns are also changing. Assuming that the building's design was optimized based on historical climate data, the overall resilience of that building to temperature variations could also be changing. In other words, the "habitat" of the building may shift in significant ways over its lifetime.

The extreme cold snap that impacted Texas in February 2021 is a recent example of unusual weather and its impact to the larger region. The average housing stock in Texas was not built with these sorts of extremes in mind. The cold snap was also accompanied by extensive power outages forcing many residents to use their cars, shelters and other heated venues (such as stores) to stay warm.[42]

Another example is the heat dome that settled over the Pacific Northwest in June 2021. A long-duration, intense heat wave described as a one-in-1,000-year event that resulted in temperatures as high as 120 degrees F in areas known for much more moderate weather.[43] The lack of adequate cooling infrastructure in buildings exacerbated the overall situation and forced many to find shelter.

Immediate relief from these events include increased heating and cooling demands. However, those actions can result in greater carbon emissions and increase the growing energy burden low- and moderate-income families experience. While some challenges could be proactively addressed with new construction, using building codes as a lever, current building codes will have less relevance and influence with existing building stock.

42 **The devastating cold's impact on Texas, in photos**. *Vox*, February 18, 2021.

43 **3 things to know about the record-smashing heat wave baking the Pacific Northwest**. *Science News*. June 29, 2021.
Washington officially has a new all-time maximum temperature record: 120 degrees. *Yakima Herald-Republic*. February 10, 2022.

HOW BUILDING CODES INFLUENCE RESILIENCE

CONTENTS

The International Code Council, the entity responsible for overseeing the development of the International Codes (I-Codes) including the International Building Code (IBC) and International Residential Code (IRC), recently held a forum to determine how climate resilience should be incorporated into building codes. The work focused on defining the boundaries and areas of focus for the work, as reflected in Exhibit 13 below.

Exhibit 13 Resilience applied to buildings

Resilience...	Applied to buildings
...of what	Buildings or parts of buildings and the contribution this makes to the broader community.
...to what	Future extreme weather events, which are anticipated to change in frequency, duration, intensity, and/or distribution.
....when	Before (i.e., adapt), during (i.e., durability), and after (i.e., recovery), short- and longer-term.
Purpose	Health and safety of: 1 intended occupants of the building; and 2 those who rely on essential systems, services, or infrastructure provided by and from the building.

Source: Delivering Climate Responsive Resilient Building Codes and Standards: Findings from the Global Resiliency Dialogue Survey of Building Code Stakeholders in Canada, Australia, New Zealand, and the United States. November 2021.

Both operational and physical impacts were considered, as well as the recognition that the intensity and frequency of climate events will change in future years.

"Climate Resilience of Buildings is the ability of a building, structure and its component parts to minimize loss of functionality and recovery time without being damaged to an extent that is disproportionate to the intensity of a number of current and scientifically predicted future extreme climatic conditions (e.g., wildfires/bushfires, storms, hurricanes/cyclones, flooding, and heat)."[44]

However, the overall resilience of the site in which that building sits and its dependency on supporting systems (e.g., transportation, energy, water,

44 Delivering Climate Responsive Resilient Building Codes and Standards: Findings from the Global Resiliency Dialogue Survey of Building Code Stakeholders in Canada, Australia, New Zealand, and the United States. November 2021.

waste, communications) are also key determinants in a successful adaptation. In most instances, these considerations extend beyond the focus of the building code, and even when there may be a link, there may be separate regulations and governing entities.

As an example, it is well known that wildfire resilience not only depends on the building design and construction but is also determined by the amount of defensible space that surrounds the asset.[45] In California, different chapters of the law speak to each of those pieces separately. Chapter 7A covers the building itself, whereas Chapter 49 covers defensible space. In addition, there are various applicability requirements based on construction dates, locations within types of hazard zones and other jurisdictional considerations which can make it a difficult process to navigate. The International Wildland Urban Interface Code (IWUIC) addresses the building, defensible space, and community-level actions.

Finally, there is more to be done to determine minimal criteria for resilience, as well as validating some of the current practices. For example, the effectiveness of exterior sprinkler systems with respect to wildfire have not been validated, nor has the appropriateness of spacing requirements of at least thirty feet within defensible space zones or even the placement of sprinklers within residential homes.[46] And while codes and structures focus on individual structures, wildfire presents a unique problem in that the extent of wildfire resilience in your neighbor's property and building will directly impact your own resilience.[47, 48]

Codes and standards can and do play important roles in ensuring overall life safety considerations at the building level. There is an increasing awareness of needing to do more both in the face of increasing impacts from extreme weather events, as well as the need to focus more on operational considerations and performance-based standards, rather than strictly prescriptive measures.

However, the larger theme is the recognition that buildings themselves do not operate independently. Their overall resilience (and that of their occupants) is a direct result of the resilience of the land use systems, eco-

45 Defensible space is the area directly adjacent to the building and extending some distance out, in which easily combustible material is removed and/or replaced with less combustible alternatives — for example, replacing wood-based mulch with gravel. See wildfire section for more discussion.

46 Michael Gollner, Assistant Professor and Deb Faculty Fellow, Dept of Mechanical Engineering, University of California at Berkeley; email correspondence, January 10, 2022.

47 Ibid.

48 For a more in-depth and nuanced look into these issues, see "**Preparing for Disaster: Workshop on Advancing WUI Resilience**."

nomic incentives and the underlying infrastructure that connect them to the community. A truly resilient solution is one that takes this more holistic approach (as an example, see the work that the **Alliance for National and Community Resilience** is doing to link those various aspects). While the focus of this toolkit is on building codes and standards — specifically as they relate to housing — we have attempted to highlight issues that could be addressed within the codes, and those which may be better addressed by other processes.

How performance expectations are translated into codes and standards

Modern building codes can be traced back as early as 1897 with the publication of the National Electrical Code and with the model codes (the International Codes or I-Codes) appearing in 1994. The I-Codes form the basis of model building codes in the United States. The International Code Council (ICC) is the governing body who oversees these modern codes and was founded through the merger of regional code groups, The Building Officials and Code Administrators International (BOCA), the International Conference of Building Officials (ICBO) and the Southern Building Code Congress International (SBCCI).[49]

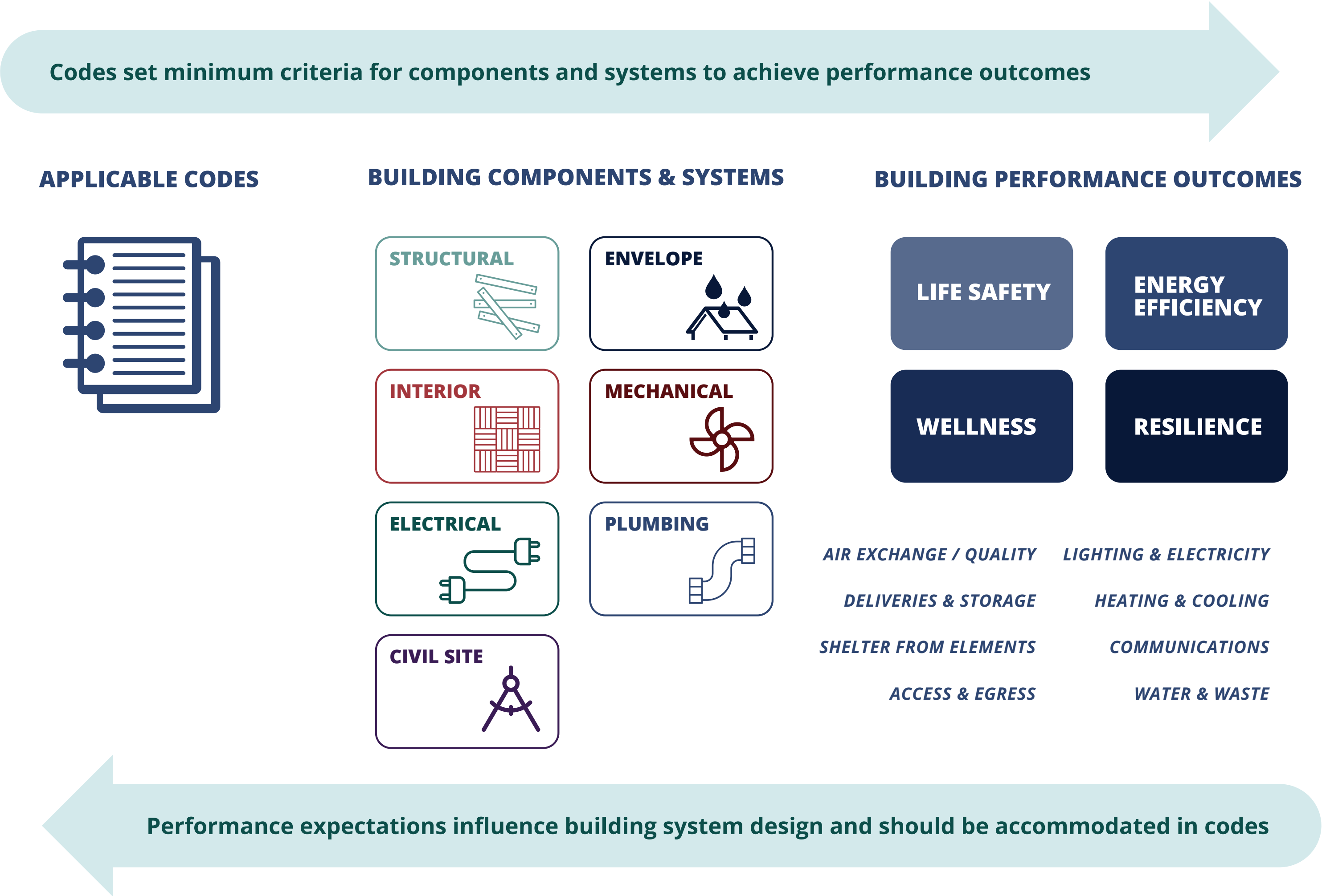
Model codes are developed through a consensus-based process across various stakeholders and are intended to serve as both a reference and minimal guideline within design and construction. The actual adoption of these codes, and turning them into regulatory requirements, happens at the state and local levels. Therefore, building design and construction types can vary considerably based not on what may be readily available through the codes (or even best practices) but on what states and local jurisdictions have decided to include as regulatory requirements. (See **Appendix A** for a summary of building code adoption per state.)

In this section, we focus more on the technical piece, specifically how performance expectations can become specific design and construction criteria that guide the building process. In the past, codes have focused more narrowly on life-safety aspects — will occupants be able to either safely shelter-in-place or exit if the building were to fail? In recent years, that focus has broadened to include other considerations such as energy efficiency, wellness, and resilience.

49 Vaughan, E., & Turner, J. (2013) "**The Value and Impact of Building Codes**." Environmental and Energy Study Institute.

Particular operational aspects must be optimized for the building to meet these performance standards. Key aspects are highlighted in the graphic below, but the list is definitely longer. There various building components and systems must be configured in such a way that they act in unison to support these building expectations. The major systems are highlighted below in Exhibit 14. The codes provide the translation of these base performance expectations to the various building systems and offer guidance on how to achieve those results. Building standards take that higher-level guidance offered within the model codes and provides detailed design and construction methodologies for use by the professional engineer, architect, and builder.

Exhibit 14 The relationship among codes, building design and performance outcomes



As shown in Exhibit 15, the ICC model codes often reference other codes and standards with respect to design and construction requirements. This helps in streamlining the various requirements across a variety of disciplines and ensuring alignment with standard practices. Again, there is flexibility at the state level and in home-rule jurisdictions to adopt some (or none) of the codes, as well as which standards they will include as part of those incorporations. The graphic below represents how individual standards align with different building systems, but it should not be read as what is adopted within each jurisdiction.

Exhibit 15 **A crosswalk showing the relationship across hazard types, building components, and relevant codes and standards**

REFERENCED CODES AND STANDARDS

	STRUCTURAL	ENVELOPE	INTERIOR	MECHANICAL	ELECTRICAL	PLUMBING	CIVIL SITE
FLOOD	ASCE 24			IMC, UMC	NEC	IPC, UPC	ASCE 24
FIRE	Int. WUIC, NFPA 1140	Int. WUIC, NFPA 1140	NFPA 1140	Int. WUIC, NFPA 1140	NEC, NFPA 1140		Int. WUIC, NFPA 1140, IFC
TEMP		ASHRAE 90.1, IECC	ASHRAE 90.1, IECC	ASHRAE 90.1, IECC	ASHRAE 90.1, IECC	ASHRAE 90.1, IECC	
WIND	ASCE 7	ASCE 7					

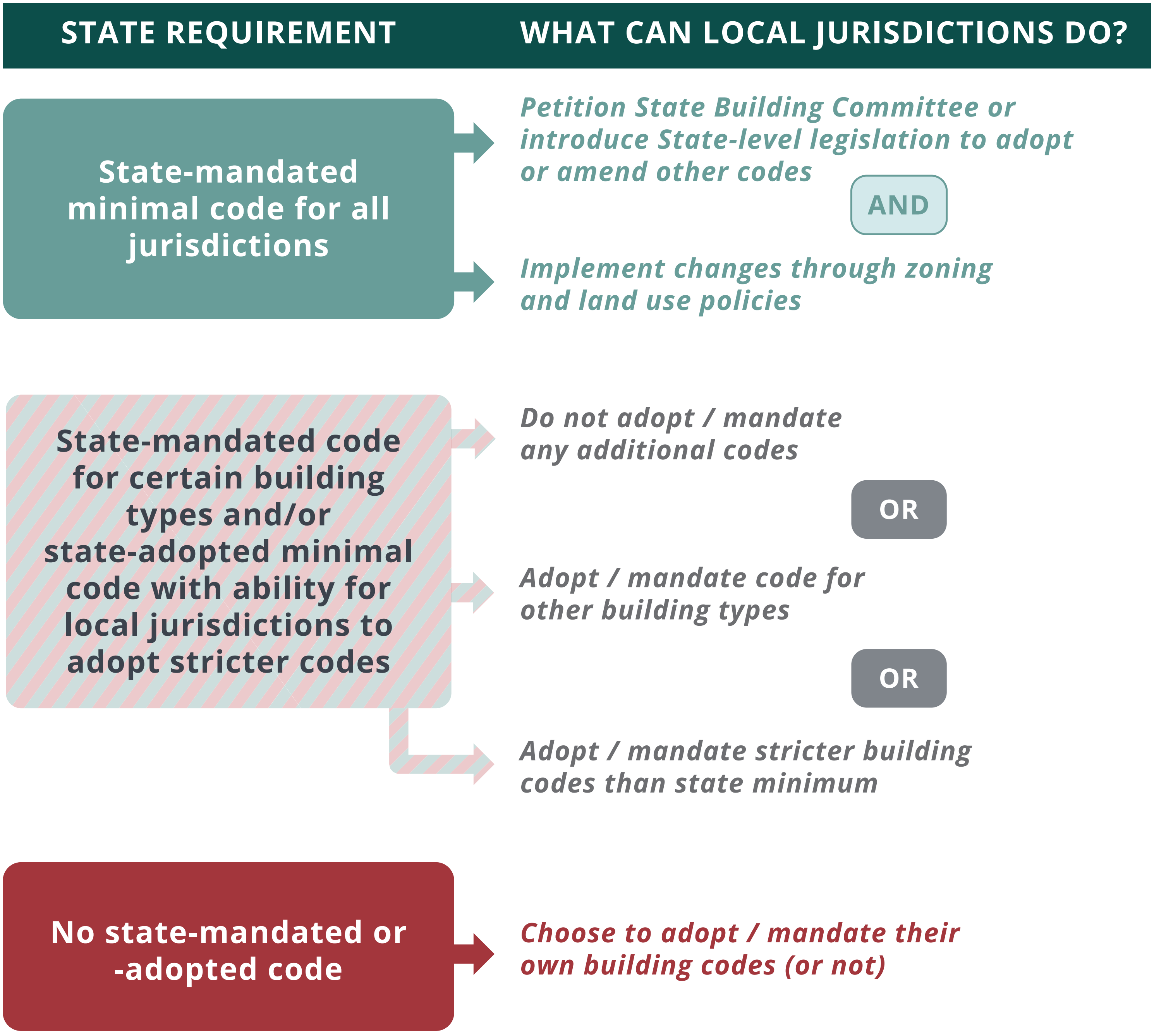
Note: NFPA 1141 and NFPA 1144 have been incorporated into NFPA 1140, Standard for Wildland Fire Protection.

There have been changes in what the codes cover with respect to climate-related hazards. A summary of some of the most significant changes for each hazard is available in **Appendix C**.

How building codes are adopted at the state and local levels

Building codes are governed at the state level, each state having its own set of detailed rules. The following represents the continuum of possible governance structures and extent of legal authority that local jurisdictions have in adopting and/or mandating code requirements that differ from their state.

Exhibit 16 Options for local jurisdictions depending on state code requirements



General challenges and potential solutions

Challenge: There is a general perception that building to a more resilient standard will involve more costly solutions. This is a particularly difficult assertion to test since the data are hard to collect (no centralized or standardized reporting platform exists for this information), there are few resources that have been invested in underwriting these types of studies, and those studies that have been conducted may not be well-socialized across the larger industry and/or within the public realm. With a readily available source of peer-reviewed work, volunteer-led planning boards do not have the capacity to challenge this perception. Likewise, without a readily available set of design and construction codes (or guidance), developers and contractors are not likely to take the risk of doing things differently.

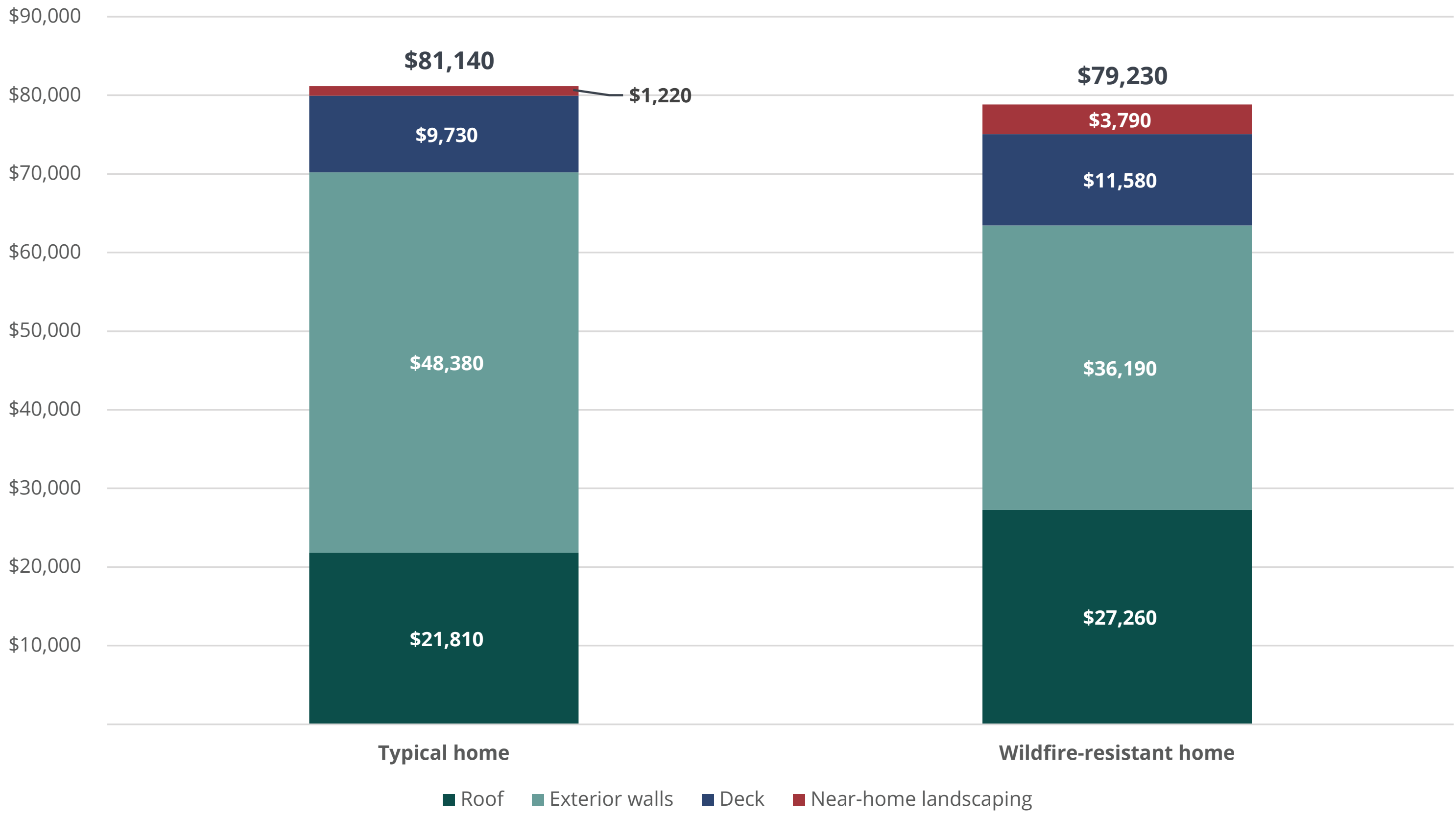
At the national level, building codes are enacted through a committee-based forum where changes are proposed by groups representing a variety of interest, ranging from safety and insurance representatives to engineers to professional organizations representing home builders and manufacturers of building supplies or individuals and then voted on by individuals representing jurisdictions throughout the country.

In general, homebuilders and developers can be reluctant to adopt additional codes because of the fear that they may add additional complexity and cost to the building process which could make the price of homes more expensive and less affordable. This is often the key area of conflict in proposing new changes to the code.

Solution: There needs to be a concerted effort to test the validity of this perception and to provide **cost–benefit analysis of more resilient building codes.** A recent **research effort** between Headwaters Economics and IBHS revealed that with wildfire construction, it can actually be *less* expensive to build to resilient standards than traditional builds.[50] The results of that work have been summarized in a readily accessible format and with adequate detail to support decision-makers as they consider whether or not to adopt more stringent standards than what may be available in the base model codes. The **NIBS study** found that updated codes added just one to two percent to the construction costs while capturing benefits for all stakeholders (builders, owners, tenants, financiers, and the community). A **study in Moore, OK,** following a code update after a string of tornadoes found no impact on price per square foot or home sales. This is representative of the type of work that needs to be done more widely throughout the industry, across the various hazards.

50 Headwaters Economics, 2018. **Building a Wildfire-Resistant Home: Codes and Costs**.

Exhibit 17 New construction costs by component in typical home and wildfire-resistant home



Source: Headwaters Economics. Building a Wildfire-Resistant Home: Codes and Costs.

Challenge: The criteria used to conduct fiscal impacts of new building codes may not include appropriate metrics and/or may result in unintended consequences. This is especially true with equity considerations and the ability to pay.

EXAMPLE OF UNINTENDED CONSEQUENCES AND EQUITY CONSIDERATIONS

St. John's County in Florida recognized the need to amend the current Florida Building Code to allow for residents to address storm-related damages without having to necessarily build to newer code requirements. The existing code required that the owner build to current-day codes if there were improvements that resulted in greater than 50 percent of the value of the resource over five years. Eligible upgrades included any type of improvements– not only those associated with storm damage. These originally well-intention actions created situations where less-resourced households could not afford to repair their homes following a storm event. The proposed reduction in standards would remove the requirement to enforce cumulative substantial improvement requirements. It also pointed to the need of solving more creatively for sea level rise and other types of resilience so that low- to moderate-income individuals have the same access to resilience interventions as others.

Some people interviewed as part of this work also highlighted how the current BRIC rating system used to rank the overall desirability of a proposal, awards as many as 20 points to jurisdictions that already have advanced building codes in place. This is meant to incentivize resilience but can also create the unintended consequence of making it more difficult for those municipalities with fewer resources to compete for funding. It has the potential to create a competitive advantage for those communities which may have the means to pursue more progressive codes instead of having the BRIC program invest more heavily in those that are interested but may not necessarily have the capacity to make the change on their own.

Solution: It is important to be **well-versed in the metrics used to underpin these calculations associated with affordability and equity,** where those data are sourced, and if any unintended consequences of the current ranking system would necessarily preclude the same outcomes each time. Several examples across the resilience field show where traditional cost–benefit analyses unfairly weight certain aspects more heavily than others. In many cases, these weightings could both limit the range of potential solutions and/or discount what should be significant considerations. An example of the latter includes basing the benefits heavily on the value of property at risk which often results in minimizing the impacts to low-moderate income populations and/or people who do not own property. Ideally, the entire community should be involved in code and policy related to development. This requires providing resources and accommodations (such as food, transportation, and childcare) to participants to ensure as many people as possible can be engaged.

Challenge: The overall structure of the governance and approval process will necessarily influence what gets introduced for consideration, how it is framed, and who has final say on what passes and what does not. Model and adopted codes are products of negotiations where a variety of stakeholders and perspectives can influence the outcome. The underlying governance associated with those negotiations, including how the discussions are held, who can participate, and how the approval process is determined, including who can votes and how votes are weighed, all influence the dynamics and eventual outcomes of these process.

Increasing attention has been paid to these processes, especially with respect to resilience. More specifically, when local entities are looking to create a higher standard of resilience than what currently exists in base codes. Examples of that include controversy around the ICC's recent changes in governance systems related to energy efficiency code approvals. The concern was that the change resulted in a process that will hinder a local governments' ability to adopt more progressive codes with respect to energy use and mitigation.[51]

Solution: Resilience enhancements can be further leveraged within the current system in parallel with the types of efforts described above. Examples of working within the current system include the work that ICC is doing in partnership with ANCR to create community-wide benchmarks for resilience working through a codes **framework**, as well as its recent publications around the types of resilience measures that currently exist within the codes.[52]

51 Chrobak, U., 2021. **Making buildings energy efficient just got harder**. *Popular Science*, March 21, 2021.

52 International Code Council, 2019. **Resilience Contributions of the International Building Code**. See also: how some aspects of the energy code also support resilience in **The Important Role of Energy Codes in Achieving Resilience**.

Exhibit 18 Aspects of resilience already captured in IBC

Selected code topic	Relevant sections (2018 IBC)	Supported resilience strategy	Relevant hazards
Critical facilities identification	307	• Emergency planning • Community operations • Response and recovery	• Flooding • Hurricanes • Tornadoes • Blizzards • Terrorism • Wildfire
Hazardous or combustible materials	413, 414	• Isolating risks	• Terrorism • Fire • Flooding • Hurricanes • Tornadoes
Storm shelters / areas of refuge	423, 1009, 1026	• Shelter in place / refuge • Robustness • Community protection	• Tornado • Terrorism • Fire
Flammability of materials	Chapters 6, 7, 8	• Fire resistance • Egress • Indoor air quality • Smoke exposure	• Fire • Secondary to other hazards
Protection of openings	Chapter 7, 1069.2	• Structural integrity • Debris impacts	• Hurricanes • Tornadoes
Fire suppression / protection, smoke control	Chapter 9	• Fire resistance • Egress • Property protection	• Fire • Secondary to other hazards
Communication	907, 908, 917	• Public safety • Evacuation	• Fire • Terrorism • Earthquake • Tsunami • Tornadoes
Means of egress	Chapter 10	• Evacuation • Fire protection • Accessibility	• Flooding • Hurricanes • Tornadoes • Blizzards • Terrorism
Accessibility	Chapter 11	• Inclusive communities • Community cohesion • Evacuation	• Public welfare • Secondary to other hazards
Occupant health	Chapter 12	• Indoor environmental quality • Indoor air quality • Access to sanitation	• Public health • Fire • Extreme heat / cold
Exterior envelope protection	Chapter 14	• Property protection • Debris impacts • Hazard spreading	• Fire • Flooding • Hurricanes • Tornadoes

Selected code topic	Relevant sections (2018 IBC)	Supported resilience strategy	Relevant hazards
Roof assembles	Chapter 15	• Fire resistance • Debris impacts • Sealing	• Fire • Hurricanes • Tornadoes • Extreme heat/ cold
Moisture protection	1209, 1402, 1503	• Durability • Mold, mildew, rot • Property protection	• Blizzards • Hurricanes • Flooding • Thunderstorms
Hazard maps	1608, 1609, 1611, 1613, 2603	• Identifying risk	• Tornado • Hurricane • Seismic • Pests • Snow • Rain
Continuous load paths	Chapter 16	• Structural integrity • Anchorage and bracing	• Earthquake • Tornadoes • Hurricanes
Identification of risk	1604.5	• Public safety • Emergency Planning	• Earthquake • Tornadoes • Hurricanes • Blizzards
Elevation of structure	1612	• Flood mitigation • Property protection	• Flooding • Hurricanes • Sea level rise
Tsunami	1615, Appendix M	• Identifying risk • Elevation above inundation • Minimum design loads • Evacuation / refuge	• Tsunami
Special inspections	Chapter 17	• Verification of performance • Structural integrity	• Earthquake • Fire
Soils and foundations	Chapter 18	• Load support • Subsidence	• Earthquake • Sea level rise • Drought • Flooding
Materials performance	Chapter 19-26	• Fire resistance • Structural integrity • Product safety	• Flooding • Hurricanes • Tornadoes • Blizzards • Terrorism • Wildfire
Safety during construction	Chapter 33	• Public safety • Fire safety • Means of egress	• Fire • Civil unrest
Fire Districts	Appendix D	• Fire safety	• Fire

Selected code topic	Relevant sections (2018 IBC)	Supported resilience strategy	Relevant hazards
Flood resistance	Appendix G	• Flood mitigation • Property protection	• Flooding • Hurricanes • Sea level rise

Source: **https://www.iccsafe.org/wp-content/uploads/19-17804_IBC_Resilience_WhitePaper_FINAL_HIRES.pdf**

Exhibit 19 Aspects of resilience captured in energy efficiency portions of the International Energy Conservation Code

Selected code topic	Relevant sections (2018 IECC)	Supported resilience strategy	Relevant hazards
Insulation	C402.2, R402.2	• Passive survivability • Reduced energy burden • Reduced grid impact • Reduced ice-dams • Reduced condensation, limiting mold and mildew	• Extreme heat / cold • Snow storms • Social resilience • Secondary impacts to all hazards
Walk-in coolers and freezers	C403.10	• Food safety / preservation	• Extreme heat • Secondary impacts to all hazards
Daylighting	C402.4.1	• Passive survivability • Reduced grid impact	• Extreme heat • Second impacts to all hazards
Window-to-wall ratios	C402.4.1, R402.3	• Passive survivability • Impact vulnerabilities	• Extreme heat / cold • Hurricanes • Tornadoes
Solar heat gain coefficient	C402.4.3, R402.3.2	• Passive survivability • Reduced grid impacts	• Extreme heat • Secondary impacts to all hazards
Solar reflectance of roof	C402.3	• Urban heat island • Passive survivability	• Extreme heat • Secondary impacts to all hazards
Air leakage	C402.5, R402.4	• Contaminants (secondary to wildfire, earthquake, etc.) • Mold and mildew (secondary to flooding, hurricane, extreme cold, etc.)	• Secondary impacts to all hazards
Pipe insulation	C404.4, R403.4	• Passive survivability • Reduced energy burden	• Extreme cold • Drought • Social resilience
On-site renewable energy	C406.5, Appendix CA, Appendix RA	• Contribute to distributed generation • Facilities islandability	• Secondary impacts to all hazards

For those entities looking to build beyond minimal code requirements, voluntary-based programs can be used to inform design and construction criteria. One example is the **FORTIFIED Home** program led by the IBHS and developed in partnership with leading industry experts. The construction method was developed to address key vulnerabilities that made buildings less able to withstand wind damage from hurricanes, tornadoes and other severe storm events. The standard includes "beyond-code" interventions that enhance a structure's overall resilience to these events, with a focus on minimizing overall damage in order to reduce (or avoid) post-event repairs, relocations or interruptions to daily living. An easy-to-use **website** allows interested parties to learn more about the program, find qualified contractors in their area and a roadmap for installing FORTIFIED products following an event. Several states have programs to incentivize the up take of these types of interventions, including providing grants as well as tax and insurance incentives (see "**Wind - Extreme Events**" on page C23 for more details).

Chris Sutton flickr.com/photos/xpinger/24003223577

Another benefit of **FORTIFIED Home** is that it offers standards to address hail damage. Hail is a big source of damage to structures but is not seen as a widespread health and safety issue because people can seek shelter so it is not specifically included in building codes.

Exhibit 20 FORTIFIED Home

The National Standard for Resilience	FORTIFIED Roof	FORTIFIED Silver	FORTIFIED Gold
Enhanced roof deck attachment			
Sealed roof deck			
Locked down roof edges			
Impact-resistant Shingles Rated by IBHS			
Wind- and rain-resistant attic vents			
Impact protection for windows and doors*			
Impact* and pressure-rated garage doors			
Chimney bracing			
Reinforced soffits			
Anchored attached structures			
Gable end bracing			
Pressure-rated windows and doors			
Stronger exterior sheathing			
Engineered roof-to-wall connections			
Engineered story-to-story connections			
Engineered wall-to-foundation connections			

Source: FORTIFIED Home

Challenge: It can take as many as three years (sometimes more) for changes in model building codes to be incorporated at the state or local level. It is necessary for the jurisdictions to amend and adopt the new editions before the changes are applicable. This process can take several years.

Solution: States and municipalities can shorten that time by **enacting a process by which a new code is adopted within a set timeframe after publication of a model code within 18 months.** The update process typically includes procedures for amending content in the model code to meet state or local requirements. Additionally, in states where local governments can adopt their own codes, municipalities can amend the codes according to their own schedules and/or needs (see **Appendix A** and **Appendix B** to learn more about code governance structures in each state).

Challenge: Having adequate capacity to ensure enforcement of building codes is a challenge for many states and municipalities. It can be a tedious and overwhelming proposition to ensure compliance for all new developments, even in states where the code only applies to certain structure types. Some municipalities have adequate capacity. In other cases, county, state and/or council of governments may have "circuit-riding" inspectors to carry out local inspections. The enforcement process ensures what was designed actually gets built.

Solution: The enforcement of building codes during design and construction requires adequate technical expertise, capacity, and budgets to allow for inspections during and post-construction. Assuming budget constraints will drive the capacity of local and state jurisdictions to properly inspect new and renovated facilities, there are options available that can be introduced into the codes at the local or state level. These options include using the affidavit process to assure conformance or allowing inspection by third party organizations.

In the affidavit process the designers of the facilities are responsible for assuring the structures are designed and constructed in accordance with the applicable codes. Members of the design team provide affidavits when the construction documents are submitted for permit. The affidavit indicates the design documents are in conformance with the applicable codes.

The challenge with the affidavit process is that it relies on the technical expertise of the designers or other parties and their knowledge of the applicable codes. Compliance needs to be tied to the professional license with sufficient mechanisms for monitoring compliance and penalties for non-compliance.

One example of this is GOVmotus, a program developed by the Institute for Building Technology and Safety (IBTS). This program allows for remote inspectional services via a hosted software platform and can be used to provide building department services, inspections and quality assurances to jurisdictions that may otherwise not have the capacity to perform these on their own.

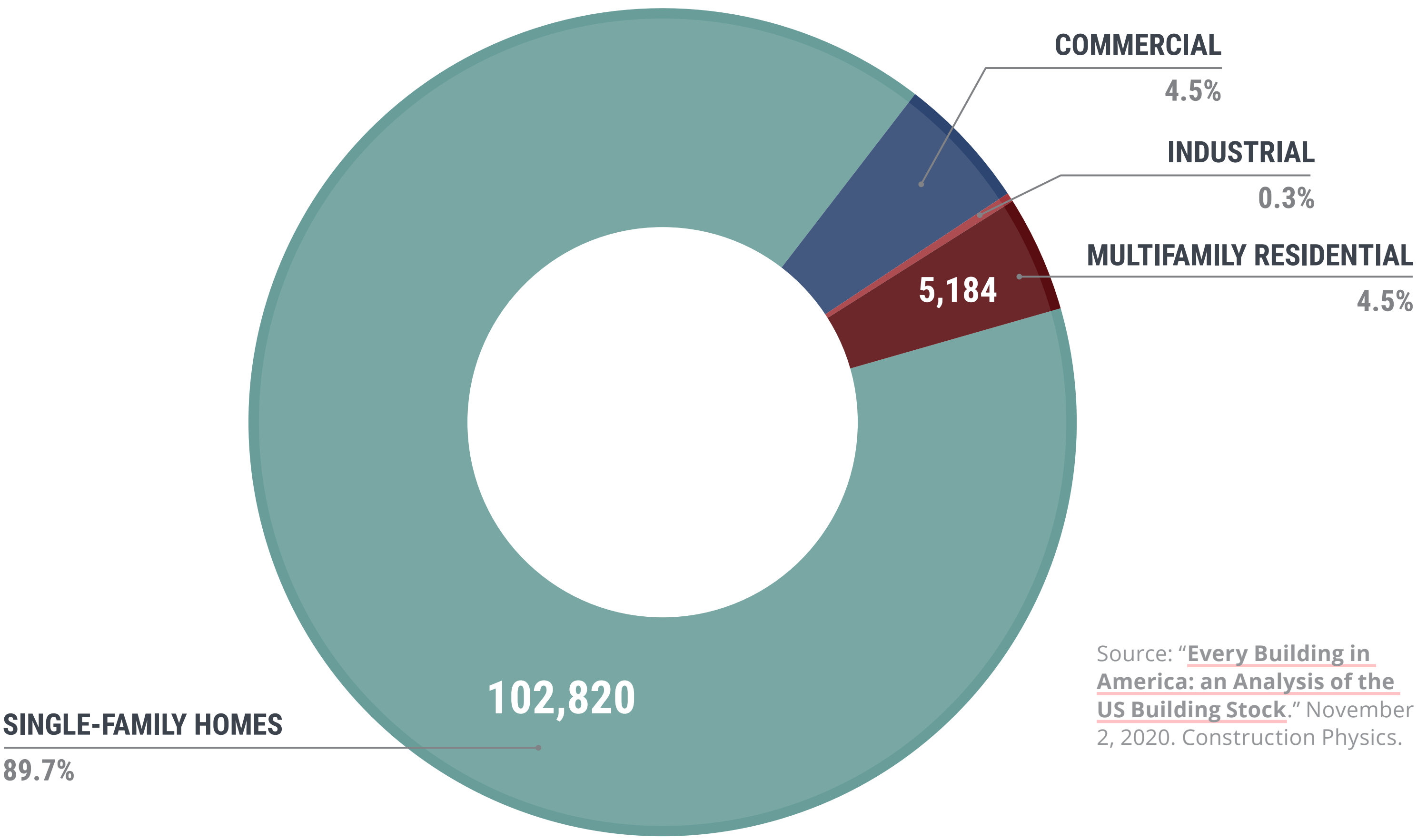
Source: **GOVmotus**

Third-party organizations can be used to supplement the capacity or expertise of the building officials. If the officials don't have the capacity or the expertise to review plans or construction, a third-party review and inspection organization can be an alternative. The cost is normally borne by the applicant. The official either has approval authority over the proposed organization or has a list of approved organizations from which the applicant can choose. The advantage of this approach is that the official can have more confidence that the organization conducting the reviews and inspecting the construction has the necessary expertise with regard to the applicable codes. The third-party organization(s) technically work for the jurisdiction, even though the cost is borne by the applicant.

Some communities have banded together to provide joint services where a single community cannot support its own building department.

Challenge: It can be difficult to address resilience in existing buildings. Approximately 111 million buildings exist in the United States, of which nearly 90 percent are single-family homes.

Exhibit 21 Number of buildings in the U.S. (thousands)



Source: "Every Building in America: an Analysis of the US Building Stock." November 2, 2020. Construction Physics.

For the most part, building codes focus almost exclusively on new construction (and or significant rehabilitations) which represent a very small percentage of the overall building stock. So, what can states and local governments do to address resilience in the existing building stock?

Solution: Municipalities have been quite creative in solving for this need using existing programs, regulatory frameworks and funding sources in slightly different ways. Below are some representative examples of how municipalities have enhanced resilience within existing building stock:

LEVERAGING CDBG-DR FUNDING TO ADDRESS RESILIENCE NEEDS IN ST. AUGUSTINE'S EXISTING BUILDING STOCK

St. Augustine, Florida, is the oldest city in America and almost at capacity as far as development is concerned. Many residents live in homes needing resilience to flooding impacts, but traditional revenue sources are insufficient to address this need.[53] Although homes built to the most recent editions of the Florida Building Code have been noted to better withstand impacts from flooding and storm damage, building code requirements do not necessarily have relevance here unless their homes experience significant damage.

The municipality used CDBG-DR funding to invest in resilience retrofits for those low- to moderate-income households that experienced repetitive losses from flooding. Possible actions included the option to demolish and rebuild, to elevate the structure or to move. Floodproofing is not recognized as eligible mitigation under FEMA programs, so this creative application of CDBG-DR funding allowed the city to address much needed resilience interventions for residents who may not have otherwise been able to access them.

MAKING THE MOST OF A NATURAL DISASTER

It is often difficult to think about long-term resilience in the immediate aftermath of a major weather event or natural disaster. However, these events can also present an opportunity to build back better *and* differently. The Federal funding that accompanies these events can be leveraged to relocate housing away from vulnerable areas and provide the required infrastructure (e.g., transportation, utilities) to keep them connected with the core community. The first reaction to a major flooding disaster may be to simply elevate the structure on the existing footprint. However, there

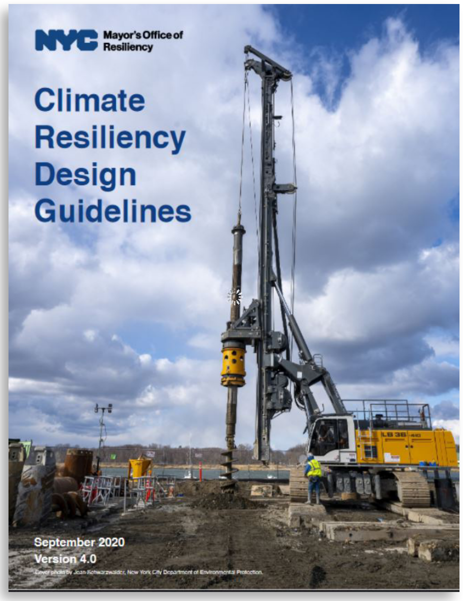
53 Personal communication, Westly Woodward, January 7, 2022

may be better solutions that involve relocating those homes to a slightly more inland area while still preserving the important community and cultural aspects of the neighborhood. When rebuilding, it will also be easier to incorporate more resilient building codes, standards and practices. While a relocation and rebuilding such as this can be challenging in dense, urban areas, less densely populated areas may offer more opportunities.

As an example, EPA has partnered with Smart Homes America and the Gulf of Mexico Alliance to proactively identify these opportunities and make the process less cumbersome for location communities. The goal is to "create community-wide ownership of a new post-disaster housing recovery plan by enabling local communities to incorporate and implement best practices in pre-disaster mitigation, policy, and planning by bridging the gap between the public and private sectors. The project will also identify missing knowledge or tools communities need to undertake disaster recovery efficiently and shorten the consistent lag time of federal aid."[54]

54 Project description from grant application, US EPA Gulf of Mexico Program, cooperative agreement #00D86619

LOCAL INITIATIVES THAT USE A COMBINED APPROACH OF LAND USE, ZONING, AND LOCAL CODE DEVELOPMENT AND ENFORCEMENT TO INCENTIVIZE THE ADOPTION OF RESILIENT BUILDING PRACTICES – IN BOTH NEW AND EXISTING STRUCTURES



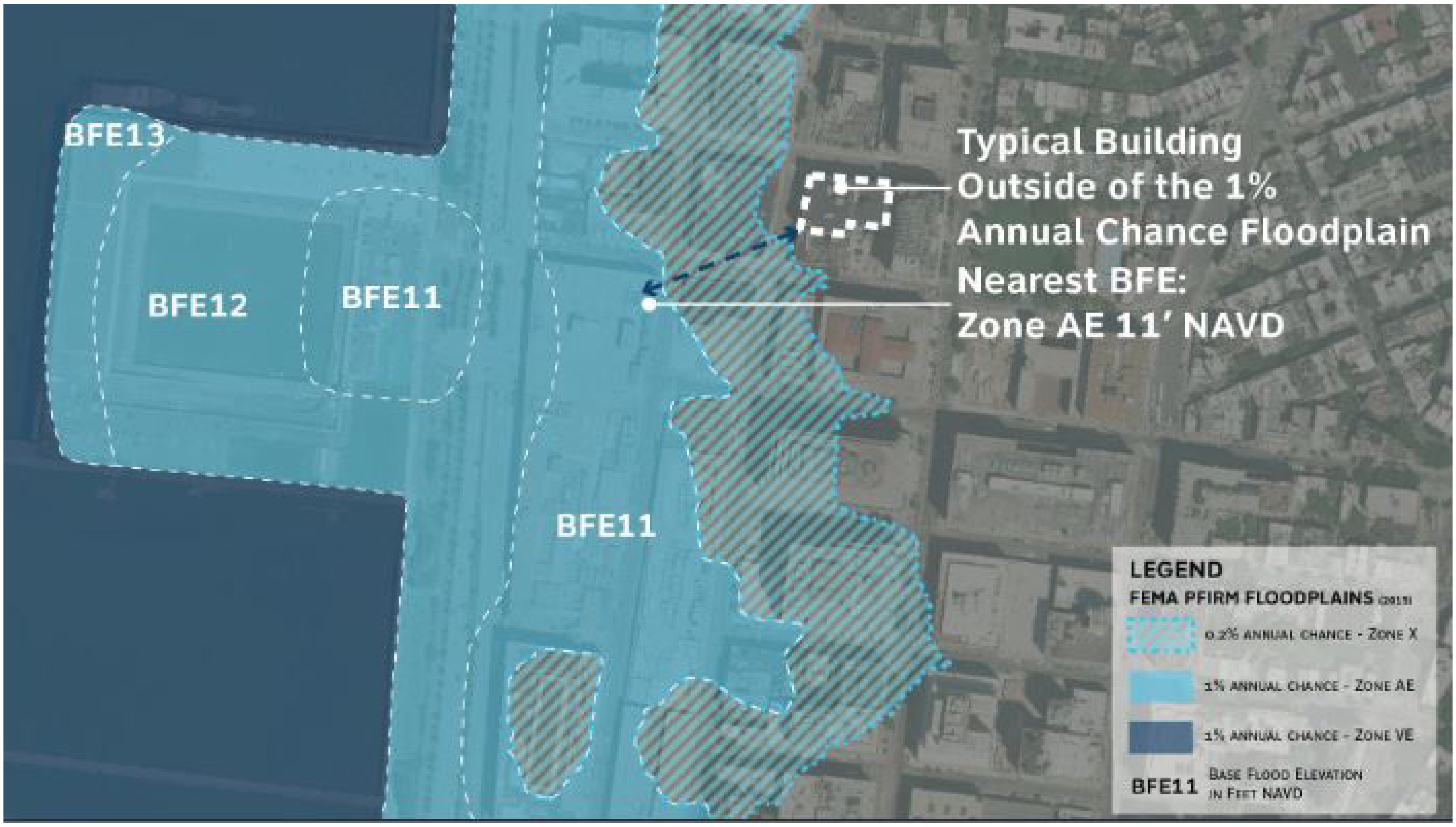
NYC'S RESILIENCE PROGRAM

New York City has taken a comprehensive approach to tackling climate change, leveraging both the existing codes structure as well as planning and land-use related interventions.

These **Climate Resilience Design Guidelines** dictate how climate change will be incorporated into city-funded capital projects. It requires that resiliency report cards be issued for all city projects and that those projects be designed to meet the design criteria outlined in the standards.

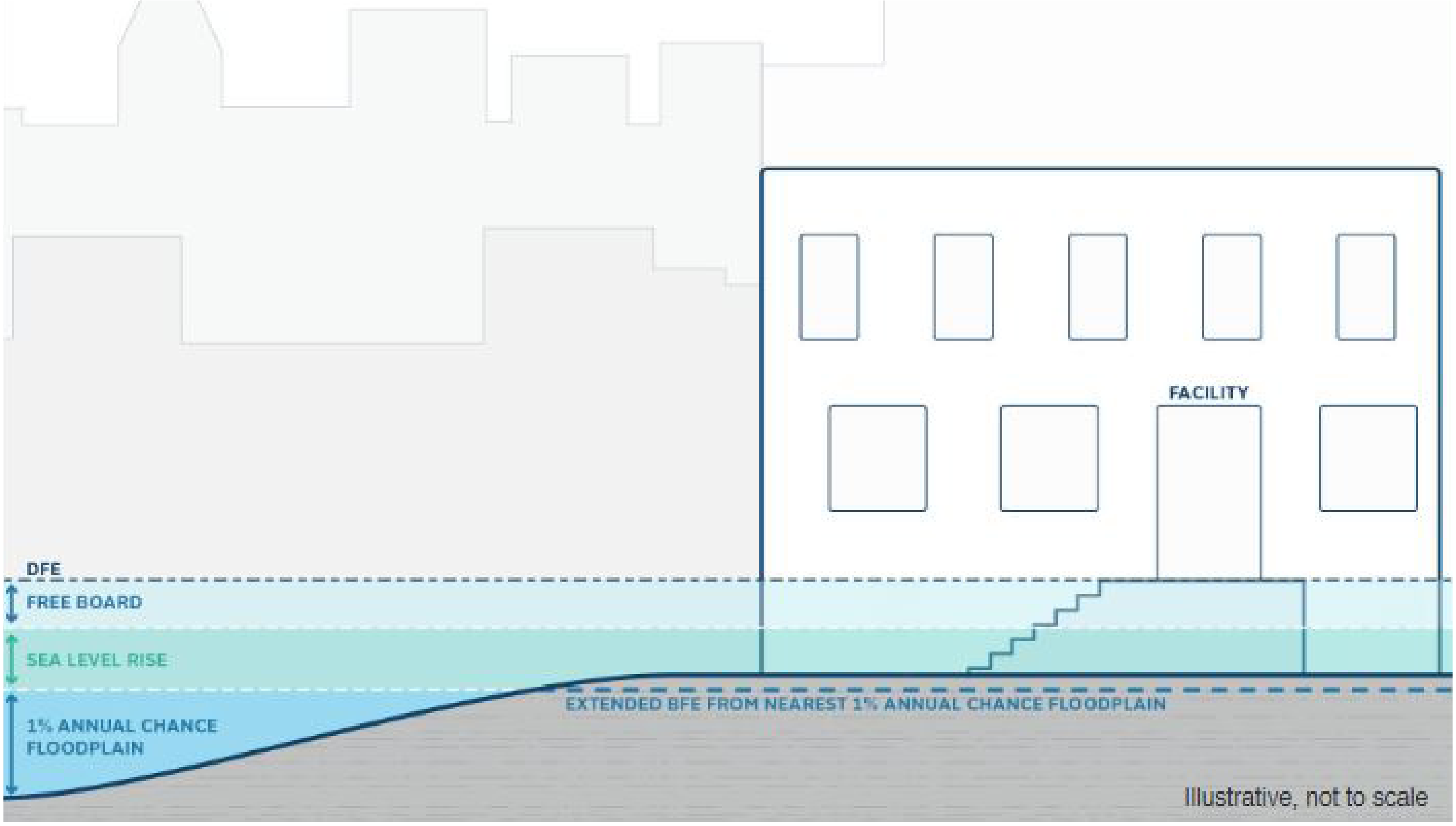
The companion piece, **Zoning for Coastal Flood Resiliency,** examines the role that land use and planning can achieve in meeting resilience objectives and proposes complementary solutions to those proposed at the building level.

Exhibit 22 **How to locate the nearest adjacent 1% floodplain elevation from a given project site**

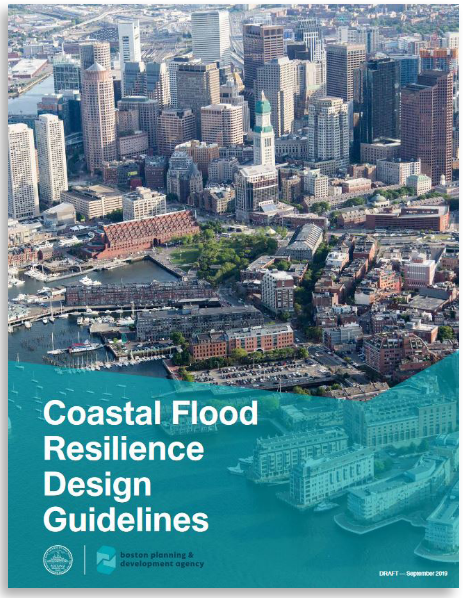


Source: NYC Climate Resiliency Design Guidelines

Exhibit 23 **How to use a base flood elevation in the current floodplain to determine a design flood elevation in the future floodplain**



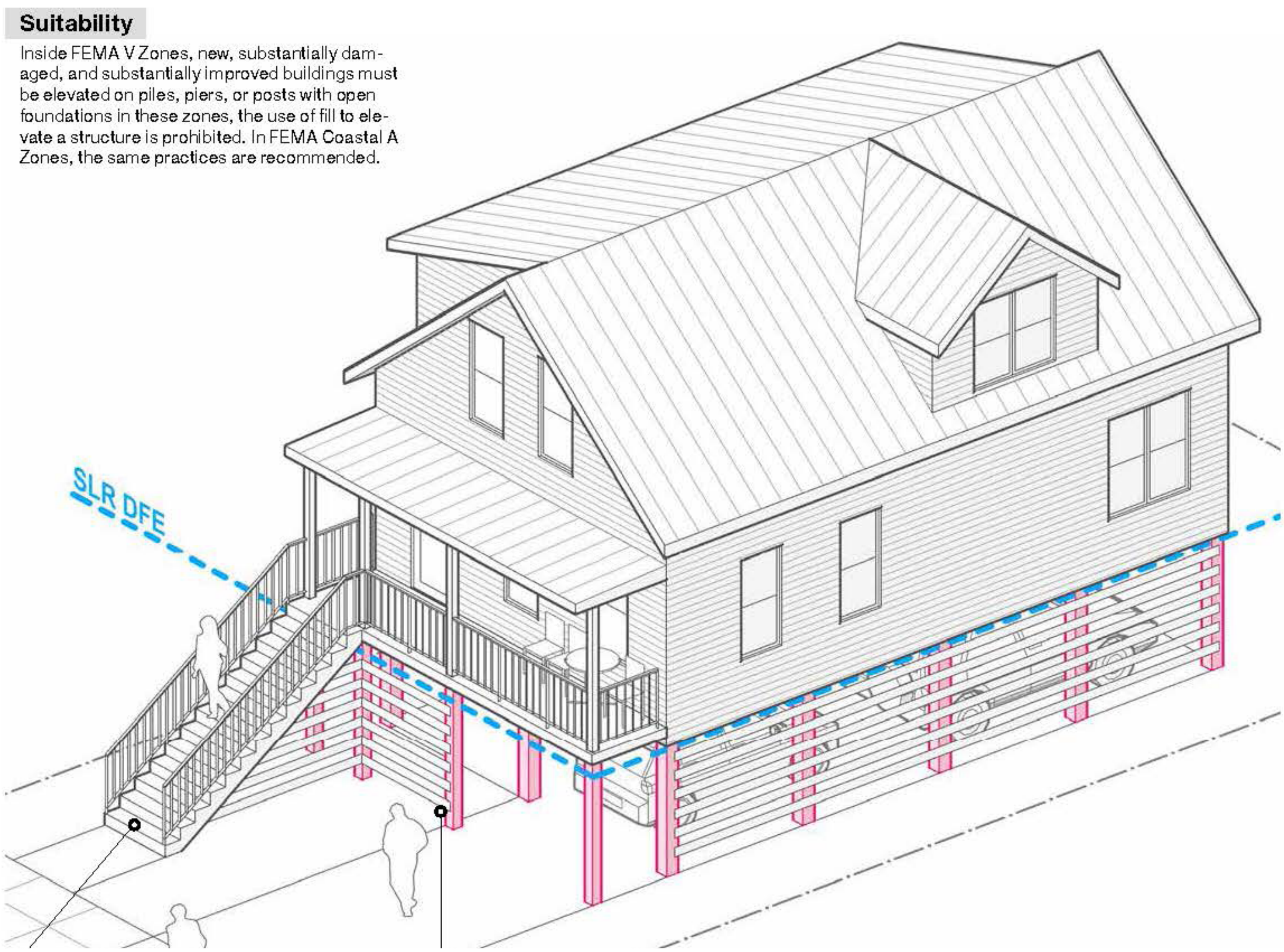
Source: **NYC Climate Resiliency Design Guidelines**



BOSTON'S COASTAL FLOOD RESILIENCE DESIGN GUIDELINES AND FLOOD RESILIENCE OVERLAY DISTRICT

Boston has adopted a similar approach to NYC in adopting both building-**specific guidance** for new construction and building within areas of the city which will be impacted by sea level rise and coastal storms, and combining those efforts with the recently adopted **Coastal Flood Resilience Overlay District** that uses climate projections to inform zoning decisions related to proposed use and dimensional aspects of buildings.

Exhibit 24 City of Boston Flood Resilience Design Guidelines



Source: **Coastal Flood Resilience Design Guidelines**

MIAMI BEACH — BUOYANT CITY

Buoyant City provides a comprehensive look, combining both land use and building code criteria, to address resilience across a variety of lenses, including within building typologies, at the level of landscapes and streetscapes, accounting for historic preservation needs and providing guidance by type and strategy.

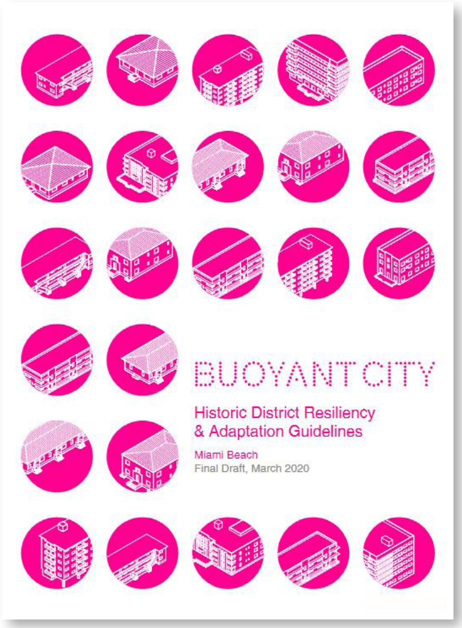
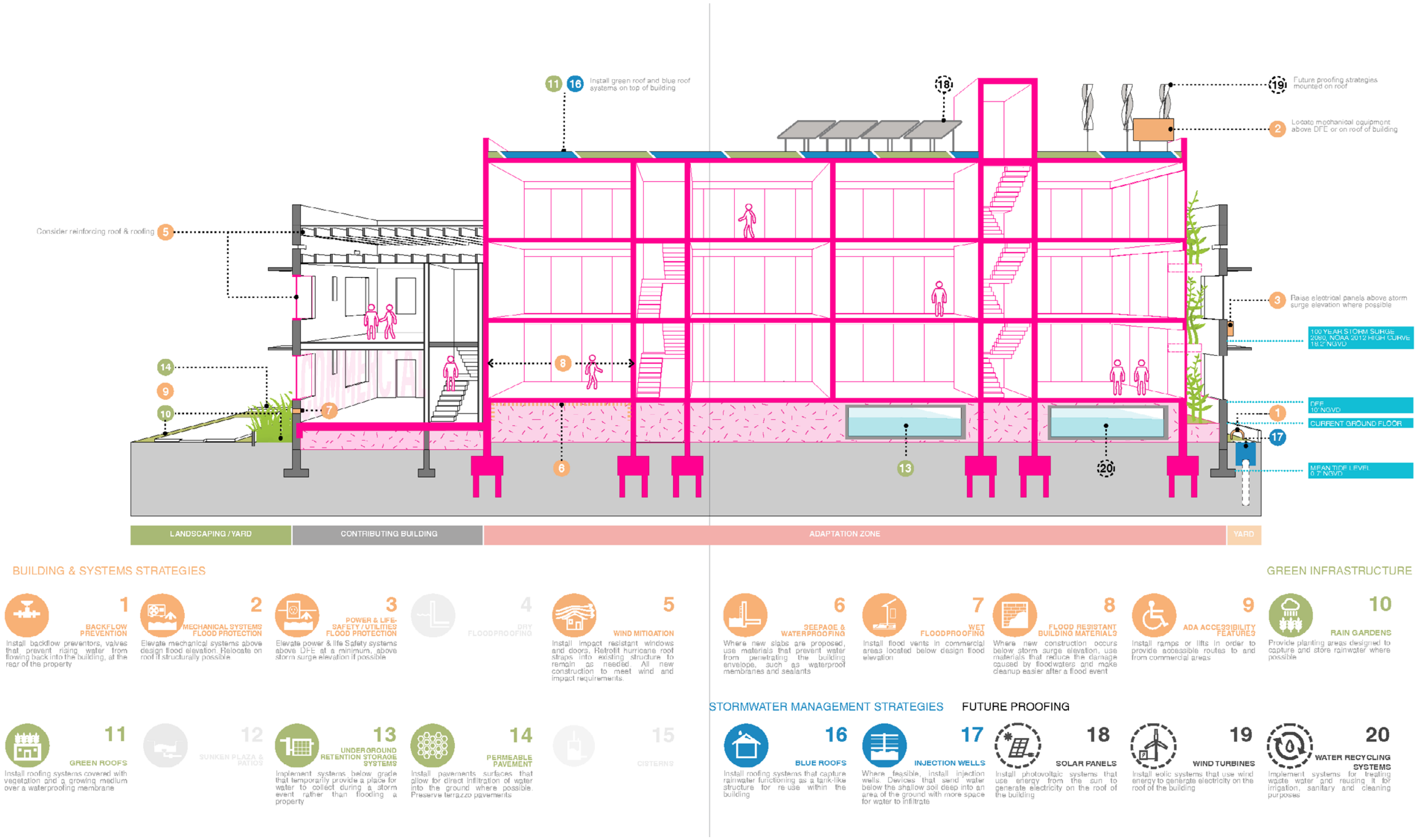


Exhibit 25 City of Miami Beach — Buoyant City



Source: Buoyant City: Historic District Resiliency & Adaptation Guidelines

Challenge: Funding and technical assistance can be an issue when moving forward with building code initiatives. States and/or communities might not have sufficient resources to take the next steps.

Solution: While building code adoption occurs at the state level, the federal government can provide additional incentives — in the form of technical support, technical capacity and funding — to help with the development and implementation of code requirements. Exhibit 26 and Exhibit 27 capture two representative resources that provide additional direction, as well as potential funding and programmatic support.

The Department of Energy **Building Energy Codes Program** (BECP) provides technical assistance and grant funding to support code adoptions and implementation. Sources include the state energy programs (SEP), energy efficiency and conservation block grants (EECBG), and the newly established energy code implementation program (EICP)."

Exhibit 26 FEMA Program Reference Matrix

Program	Flood	Fire	All hazard	Annual programming	Post-disaster	Mitigation project grants	Capability / capacity building, building code administration, & technical assistance grants	Nature-based solutions projects	Training, preparedness, technical assistance from FEMA
Sea level rise & flood maps	✓			✓					✓
Mitigation planning			✓	✓					✓
Building resilient infrastructure & communities			✓	✓		✓	✓	✓	✓
National flood insurance program	✓			✓			✓		
Flood mitigation assistance	✓			✓		✓	✓	✓	
National exercise program			✓	✓					✓
Fire-adapted communities		✓		✓					✓
Public assistance			✓		✓	✓	✓	✓	
Hazard mitigation grant program			✓		✓	✓	✓	✓	
Hazard mitigation grant program post-fire		✓			✓	✓		✓	

Source: FEMA, 2021. **FEMA Resources for Climate Resilience**.

Exhibit 27 HUD Community Resilience Toolkit

- Community Development Block Grants (CDBG)
- CDBG – Disaster Recovery
- HOME
- Section 108 loans

NON-HUD FUNDING STREAMS

STATE AND LOCAL BOND MARKET

State and local governments frequently use the bond market to finance public projects and, as a result, new bond products have emerged to fund innovative green financing solutions.

- Green bonds
- Other bonds

STATE REVOLVING FUNDS AND PUBLICALLY REGULATED BANKS

Federal financing provides initial capital for states to create revolving funds and publically regulated banks.

- Water, clean energy, and transportation state revolving funds
- Infrastructure banks
- Green banks

LOCAL AND REGIONAL FEE PROGRAMS

Regional and local governments often use fee-based programs to cover administrative and operational costs for city or county services and projects.

- Bag fees
- Stormwater fees

PUBLIC-PRIVATE PARTNERSHIPS AND OTHER FINANCIAL STRATEGIES

State and local governments can partner with the private sector to implement resilience projects.

GOVERNMENT ENTITIES AND PRIVATE FOUNDATION GRANTS

Government entities and private foundations offer financial and technical resources to advance local resilience actions.

OTHER FUNDING OPPORTUNITIES

DOE Building Energy Codes Program – technical assistance

- Energy codes, stretch codes, workforce development

Funding Streams

- State Energy Program (SEP)
- Energy Efficiency and Conservation Block Grants (EECBG)
- Energy Code Implementation Grants (in development)

Regional Energy Efficiency Organizations (REEOs)

Source: HUD Community Resilience Toolkit

Building for the Future: Five Midwestern Communities Reduce Flood Risk

This **study** is a good resource of case studies from five different municipalities that were able to leverage various sources of funding to progress flood mitigation programs within their jurisdictions.

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