National Institute of BUILDING SCIENCES

Mitigation Saves:

Federal Grants Provide $6 Benefit for Each $1 Invested

Introduction

Natural hazards present significant risks to many communities across the United States. Fortunately, there are measures governments, building owners, developers, tenants and others can take to reduce the impacts of such events. These measures—commonly called mitigation—can result in significant savings in terms of safety, prevent property loss and disruption of day-to-day life.

The National Institute of Building Sciences Multihazard Mitigation Council (MMC) undertook a study in 2017 to update and expand upon the findings of its *2005 Mitigation Saves* study on the value of mitigation. In the 2017 Interim Study, the project team analyzed two areas of mitigation programs:

- **Federal grants:** The impacts of 23 years of federal grants made by the Federal Emergency Management Agency (FEMA), Economic Development Administration (EDA) and the Department of Housing and Urban Development (HUD), resulting in a national benefit of $6 for every $1 invested.
- **Beyond code requirements:** Designing new structures to exceed select provisions of the *2015 International Building Code* (IBC) and *International Residential Code* (IRC) and the adoption of the *2015 International Wildland-Urban Interface Code* (IWUIC). This resulted in a national benefit of $4 for every $1 invested.

Results of Federal Grant Programs

Considering the subtotal for the past 23 years of federally funded natural hazard mitigation, at the cost-of-borrowing discount rate, the analysis suggests that society will ultimately save $6 for every $1 spent on up-front mitigation cost. The past 23 years of federally funded natural hazard mitigation is estimated to prevent deaths, nonfatal injuries and PTSD worth $68 billion, equivalent to approximately 1 million nonfatal injuries, 600 deaths and 4,000 cases of PTSD. Table 1 provides benefit-cost ratios (BCRs) for each natural hazard the project team examined. Figure 1 shows the contributions to the calculation of these benefits.

The federal agency strategies consider 23 years of public sector mitigation of buildings funded through FEMA programs including the Flood Mitigation Assistance Grant Program (FMA), Hazard Mitigation Grant Program (HMGP), Public Assistance Program (PA) and Pre-Disaster Mitigation Grant Program (PDM), plus the HUD Community Development Block Grant Program (CDBG) and several programs of the EDA. Barring identification of additional federal data sets or sources of federal mitigation grant and loan funding, these analyses represent essentially the complete picture of such mitigation measures. In the future, the project team might also look at mitigation measures directly implemented by federal agencies.[1] Results represent an enhanced and updated analysis of the mitigation measures covered in the 2005 study. Public-sector mitigation strategies include:

- For flood resistance, acquire or demolish flood-prone buildings, especially single-family dwellings, manufactured homes and 2- to 4-family dwellings.
- For wind resistance, add shutters, safe rooms and other common measures.
- For earthquake resistance, strengthen various structural and nonstructural components.
- For fire resistance, replace roofs, manage vegetation to reduce fuels and replace wooden water tanks.

[1]Such measures include U.S. Army Corp of Engineers levees and other water management programs; National Oceanic and Atmospheric Administration early warning systems for weather; and U.S. Department of Agriculture (USDA) Forest Service prescribed burns.

The national-level BCRs aggregate study findings across natural hazards and across state and local BCRs. The *Interim Study* examined four specific natural hazards: riverine and coastal flooding, hurricanes, earthquakes and fires at the wildland-urban interface (WUI). Discussion of each hazard and the associated BCRs are provided in separate summaries.

Natural Hazard Mitigation Saves in Every State

Every state in the contiguous United States is estimated to experience at least $10 million in benefits from federal grants to mitigate flood, wind, earthquake, or fire at the wildland-urban interface. The majority of states enjoy at least $1 billion in benefits. Four states—Louisiana, New Jersey, New York and Texas—enjoy at least $10 billion in benefits. See Figure 2.

National Benefit-Cost Ratio Per Peril *BCR numbers in this study have been rounded	Federally Funded	Beyond Code Requirements
Overall Hazard Benefit-Cost Ratio	6:1	4:1
Riverine Flood	7:1	5:1
Hurricane Surge	Too few grants	7:1
Wind	5:1	5:1
Earthquake	3:1	4:1
Wildland-Urban Interface Fire	3:1	4:1

Table 1. Benefit-Cost Ratio by Hazard and Mitigation Measure.

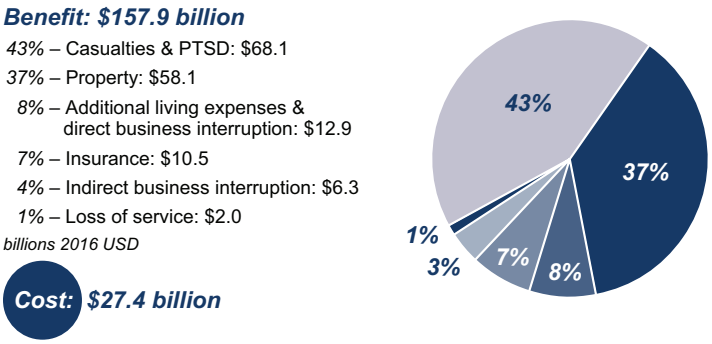

Figure 1. Total costs and benefits of 23 years of federal mitigation grants.

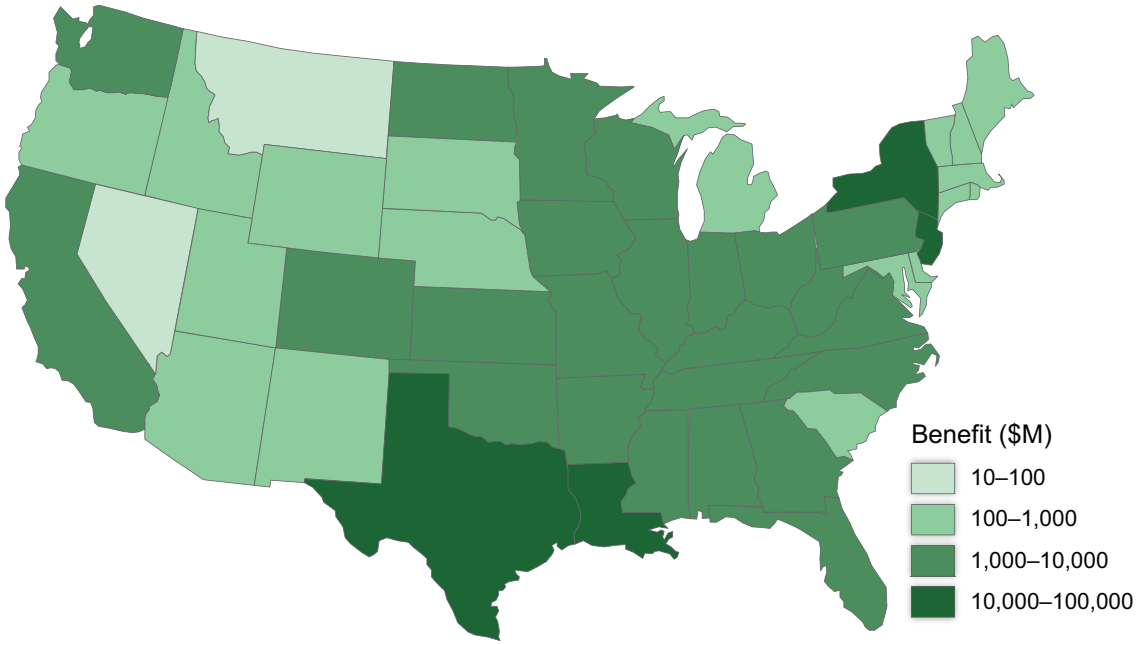

Figure 2. Aggregate benefit by state from federal grants for flood, wind, earthquake, and fire mitigation.

National Institute of BUILDING SCIENCES

Mitigation Saves:

For Riverine Flood Mitigation, Federal Grants Provide $7 Benefit for Each $1 Invested

Introduction

Natural hazards present significant risks to many communities across the United States. Fortunately, there are measures governments, building owners, developers, tenants and others can take to reduce the impacts of such events. These measures—commonly called mitigation—can result in significant savings in terms of safety, prevent property loss and disruption of day-to-day life.

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Results of Federal Grants for Flood Mitigation

The public-sector mitigation strategy examined for flood resistance is the acquisition or demolition of flood-prone buildings, especially single-family dwellings, manufactured homes, and 2- to 4-family dwellings. While the benefit-cost ratio (BCR) varies across projects, public-sector mitigation spending for the acquisition of buildings exposed to riverine flooding appears to be cost-effective. The average BCR across the sample projects is approximately 7:1. The implication is that past federally funded riverine flood mitigation is cost-effective (at the cost-of-borrowing discount rate). Given that the total cost of all riverine flood-mitigation grants was $11.5 billion, a BCR of 7:1 implies that federally funded flood mitigation will ultimately save the United States $82 billion. Table 1 provides BCRs for each natural hazard the project team examined. Figure 1 shows the benefits specifically attributable to federal flood mitigation grants. The national-level BCRs aggregate study findings across natural hazards and across state and local BCRs.

Mitigation Saves:

For Riverine Flood Mitigation, Federal Grants Provide $7 Benefit for Each $1 Invested

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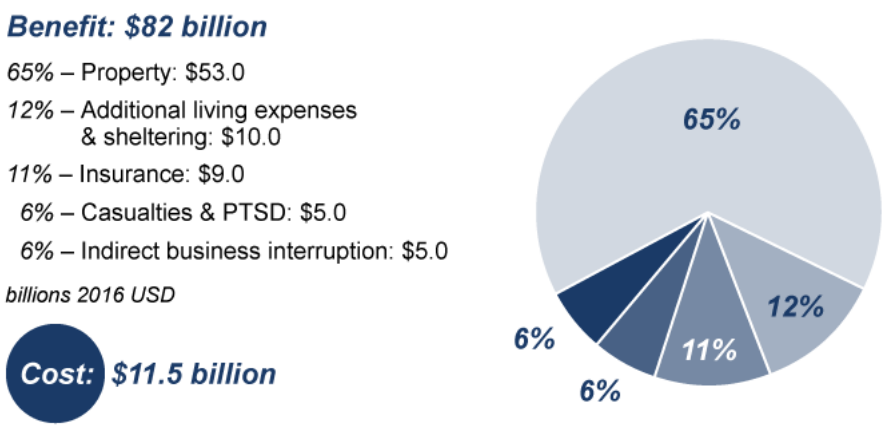

Figure 1. Contribution to benefit from federally funded riverine flood grants.

National Institute of BUILDING SCIENCES

Mitigation Saves:

For Wind Mitigation, Federal Grants Provide $5 Benefit for Each $1 Invested

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Results of Federal Grants for Wind Mitigation

Federal grants to mitigate wind damage are highly cost-effective. In 23 years, public entities have spent $13.6 billion to mitigate future wind losses; these efforts will ultimately save the United States an estimated $70 billion in avoided property losses, additional living expenses, business impacts, and deaths, injuries, and post-traumatic stress disorder (PTSD). Their total benefit-cost ratio (BCR) is approximately 5:1.

For wind resistance the mitigation measures examined include the addition of shutters, safe rooms, and other common measures. Table 1 provides BCRs for each natural hazard the project team examined. Figure 1 shows the benefits specifically attributable to federal flood mitigation grants. The national-level BCRs aggregate study findings across natural hazards and across state and local BCRs.

The estimated BCR depends largely on the level of hazard, alternative use of the facility, and accessibility. In-home safe rooms generally appear to be cost-effective, exhibiting an average BCR of 4.25. Large facilities with dual purposes, such as school gymnasia and cafeterias, exhibit an average BCR of 8.0. In these cases, the cost of mitigation is simply the additional cost of hardening the facility.

Accessibility and use also strongly affect cost-effectiveness. For example, a shelter located at a hospital will likely protect life at any time of day throughout the year. Shutters appear to be highly cost-effective, particularly those that protect valuable equipment at utilities or industrial facilities. Shutters for ordinary public buildings without high-value contents produce a lower but still impressive BCR (about 3.5).

Mitigation Saves:

For Wind Mitigation, Federal Grants Provide $5 Benefit for Each $1 Invested

National Benefit-Cost Ratio Per Peril *BCR numbers in this study have been rounded	Federally Funded	Beyond Code Requirements
Overall Hazard Benefit-Cost Ratio	6:1	4:1
Riverine Flood	7:1	5:1
Hurricane Surge	Too few grants	7:1
Wind	5:1	5:1
Earthquake	3:1	4:1
Wildland-Urban Interface Fire	3:1	4:1

Table 1. Benefit-Cost Ratio by Hazard and Mitigation Measure.

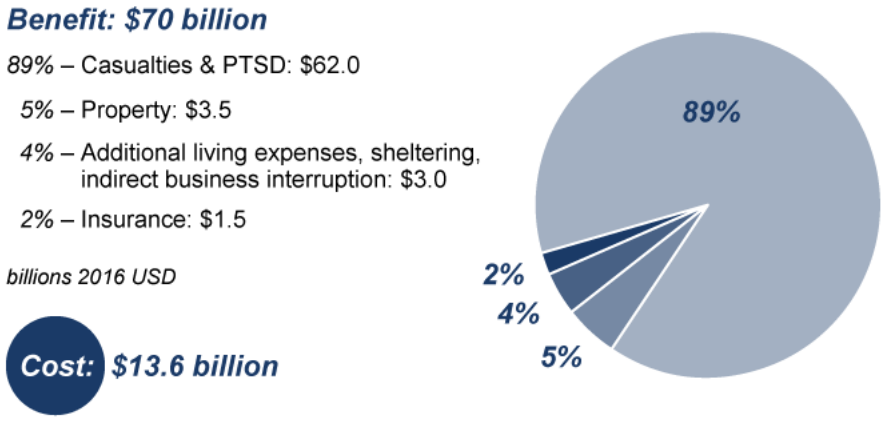

Figure 1. Contribution to benefit from federally funded wind grants.

National Institute of BUILDING SCIENCES

Mitigation Saves:

For Earthquake Mitigation, Federal Grants Provide $3 Benefit for Each $1 Invested

Introduction

Natural hazards present significant risks to many communities across the United States. Fortunately, there are measures governments, building owners, developers, tenants and others can take to reduce the impacts of such events. These measures—commonly called mitigation—can result in significant savings in terms of safety, prevent property loss and disruption of day-to-day life.

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Results of Federal Grants for Earthquake Mitigation

Considering mitigation costs totaling $2.2 billion, the average benefit-cost ratio (BCR) of approximately $3 to $1 implies that federally funded earthquake hazard mitigation between 1993 and 2016 saves society $5.7 billion.

For earthquake resistance the mitigation measures examined include strengthening various structural and nonstructural components. Table 1 provides BCRs for each natural hazard the project team examined. Figure 1 shows the benefits specifically attributable to federal earthquake mitigation grants. The national-level BCRs aggregate study findings across natural hazards and across state and local BCRs.

As with the 2005 study, property benefits alone do not equal mitigation cost, but the sum of property and casualties do. By adding other societal benefits—business interruption losses and especially loss of service to society—earthquake mitigation more than pays for itself. That observation reinforces the notion that earthquake risk mitigation broadly benefits society. That is, strengthen one building and the benefits extend far beyond the property line: to the families of the people who work in the building and to the community that the building serves.

Mitigation Saves:

For Earthquake Mitigation, Federal Grants Provide $3 Benefit for Each $1 Invested

National Benefit-Cost Ratio Per Peril *BCR numbers in this study have been rounded	Federally Funded	Beyond Code Requirements
Overall Hazard Benefit-Cost Ratio	6:1	4:1
Riverine Flood	7:1	5:1
Hurricane Surge	Too few grants	7:1
Wind	5:1	5:1
Earthquake	3:1	4:1
Wildland-Urban Interface Fire	3:1	4:1

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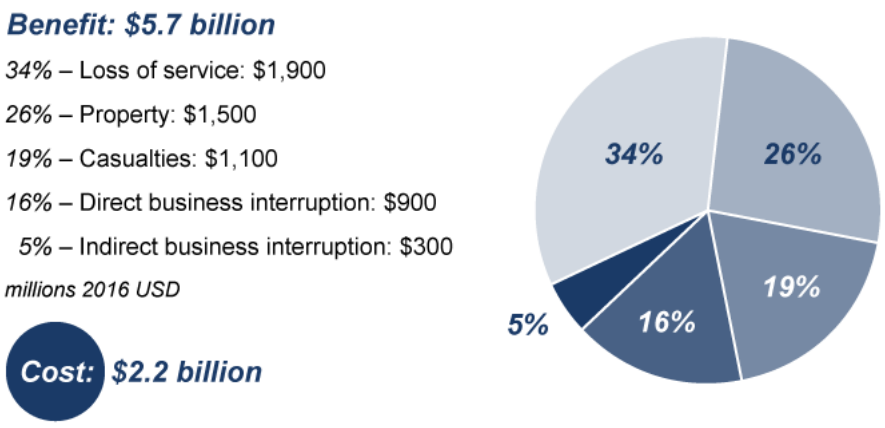

Figure 1. Contribution to benefit from federally funded earthquake mitigation grants.

National Institute of BUILDING SCIENCES

Mitigation Saves:

At the Wildland Urban Interface, Federal Grants for Mitigation of Fire Provide $3 Benefit for Each $1 Invested

Introduction

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Results of Federal Grants for Earthquake Mitigation

With a total project cost of approximately $56 million (inflated to 2016 USD), federally supported mitigation of fire at the wildland-urban interface (WUI) will save society an estimated $173 million in avoided future losses. For the 25 grants with sufficient data, the analysis produced an average benefit-cost ratio (BCR) of approximately 3:1.

For WUI fire resistance the mitigation measures examined include replacing roofs, managing vegetation to reduce fuels, and replacing wooden water tanks. Table 1 provides BCRs for each natural hazard the project team examined. Figure 1 shows the benefits specifically attributable to federal wildland fire mitigation grants. The national-level BCRs aggregate study findings across natural hazards and across state and local BCRs.

Mitigation Saves:

At the Wildland Urban Interface, Federal Grants for Mitigation of Fire Provide $3 Benefit for Each $1 Invested

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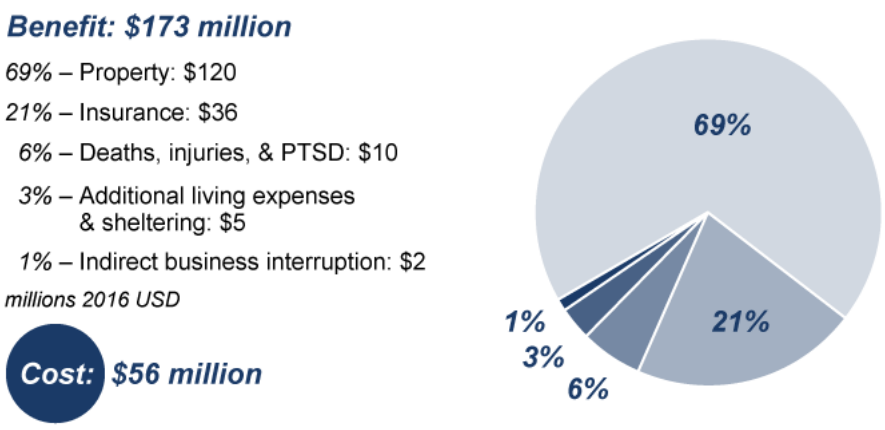

Figure 1. Contribution to benefit from federally funded WUI fire mitigation grants.

National Institute of BUILDING SCIENCES

Mitigation Saves:

Designing to Exceed 2015 Codes Provides $4 Benefit for Each $1 Invested

Introduction

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Results of Exceeding Code

If all new buildings were built to the incrementally efficient maximum (IEMax) design to exceed select requirements of the 2015 IBC and IRC and compliance with the 2015 IWUIC for one year, new construction would save approximately $4 in avoided future losses for every $1 spent on additional, up-front construction cost. Such measures are estimated to prevent approximately 32,000 nonfatal injuries, 20 deaths and 100 cases of PTSD.

Table 1 provides BCRs for each natural hazard the project team examined. Figure 1 shows the overall ratio of costs to benefits for the design of new buildings to exceed the select I-Code requirements that the project team studied. The costs reflect only the added cost relative to the 2015 IBC and IRC. Where communities have an older code or no code in place, additional costs and benefits will accrue. If all new buildings built the year after were also designed to exceed select I-Code requirements, the benefits would be that much greater, in proportion to the quantity of new buildings.

The stringency of codes adopted at the state and local level varies widely. The project team used the unamended 2015 IBC and IRC as the baseline minimum codes for this study. Minimum codes provide a significant level of safety, however, society can save more by designing some new buildings to exceed minimum requirements of the 2015 Codes. Strategies to exceed minimum requirements of the 2015 Codes studied here include:

- For flood resistance (to address riverine flooding and hurricane surge), build new homes higher above base flood elevation (BFE) than required by the 2015 IBC.
- For resistance to hurricane winds, build new homes to comply with the Insurance Institute for Business

& Home Safety (IBHS) FORTIFIED Home Hurricane standards.

- For resistance to earthquakes, build new buildings stronger and stiffer than required by the 2015 IBC.
- For fire resistance in the wildland-urban interface, build new buildings to comply with the 2015 IWUIC.

The national-level BCRs aggregate study findings across natural hazards and across state and local BCRs. The *Interim Study* examined four specific natural hazards: riverine and coastal flooding, hurricanes, earthquakes and fires at the wildland-urban interface (WUI). Discussion of each hazard and the associated BCRs are provided in separate summaries.

All Stakeholders Benefit from Mitigation Investments

All major stakeholder groups, including developers, title holders, lenders, tenants and the community, enjoy net benefits from new design to exceed the code requirements studied. See Figure 2. All of society wins when builders make new buildings meet an IEMax level of design exceeding 2015 I-Code requirements where it makes financial sense, on a societal level, to do so. The benefits to tenants and owners only accrue to those who own or occupy buildings designed to exceed 2015 I-Code requirements, not for example to the people who live or work in buildings not designed to exceed I-Code requirements. However, even those who do not own or occupy those buildings enjoy a share of the community benefits.

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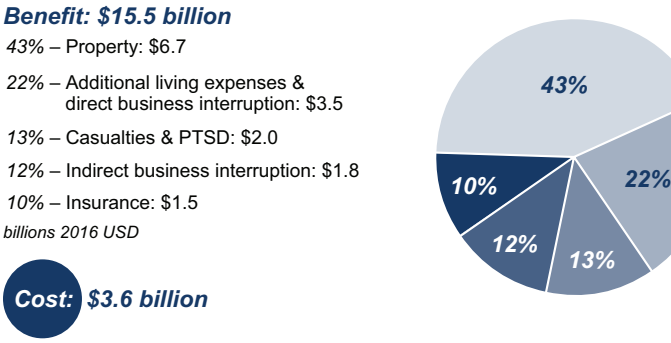

Figure 1. Total costs and benefits of new design to exceed 2015 I-Code requirements.

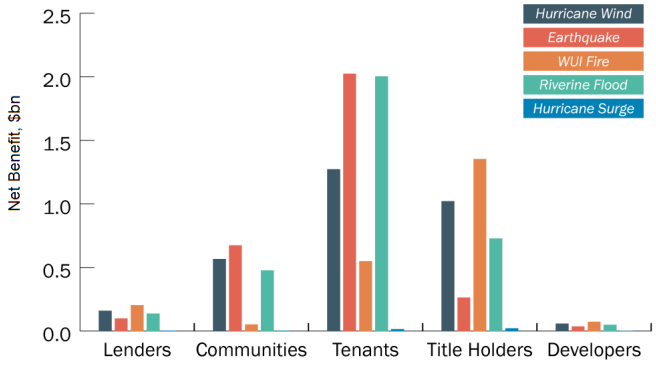

Figure 2. Stakeholder net benefits resulting from one year of constructing all new buildings to exceed select 2015 IBC and IRC requirements or to comply with 2015 IWUIC.

National Institute of BUILDING SCIENCES

Mitigation Saves:

For Riverine Flooding, Designing to Exceed 2015 Codes Provides $5 Benefit for Each $1 Invested

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Results of Exceeding Code for Riverine Flooding

The cost to build all new buildings 5 feet above the base flood elevation (BFE) for one year is approximately $900 million. This would produce approximately $4.2 billion in benefits, for an aggregate benefit-cost ratio (BCR) of approximately 5:1, e.g., $5 saved for every $1 spent to build new buildings higher out of the flood-plain.

Table 1 provides BCRs for each natural hazard the project team examined. Figure 1 shows the overall ratio of costs to benefits for the design of new buildings to exceed riverine flooding requirements of the 2015 IBC. The strategy to exceed minimum requirements of the 2015 Codes for riverine flooding is to build new buildings in the 1% annual chance floodplain higher above base flood elevation (BFE) than required by the 2015 IBC. The project team aggregated state and local BCRs to determine the national-level BCR. The costs reflect only the added cost relative to the 2015 IBC.

The stringency of codes adopted at the state and local level varies widely. The project team used the unamended 2015 IBC and IRC as the baseline minimum codes for this study. While minimum codes provide a significant level of safety, society can save more by designing some new buildings to exceed minimum requirements of the 2015 Codes. Where communities have an older code or no code in place, additional costs and benefits will accrue. If all new buildings built the year after were also designed to exceed select I-Code requirements, the benefits would be that much greater, in proportion to the quantity of new buildings.

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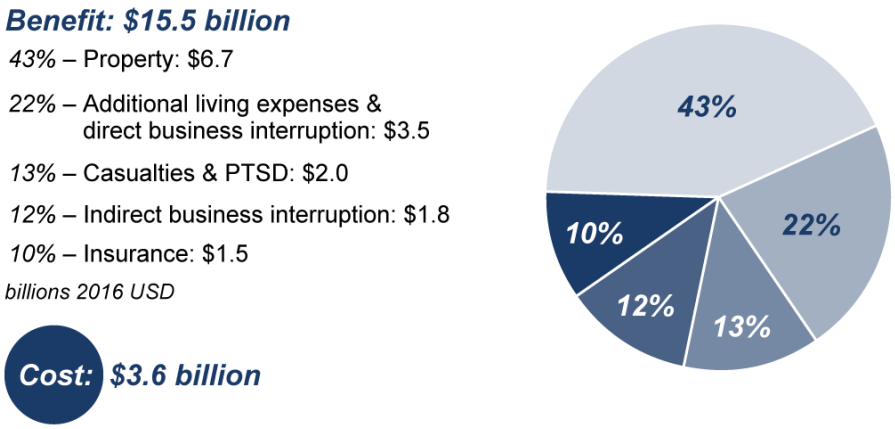

Figure 1. Nationwide benefits by category for designing to exceed 2015 I-Code requirements for flood.

National Institute of BUILDING SCIENCES

Mitigation Saves:

For Hurricane Surge, Designing to Exceed 2015 Codes Provides $7 Benefit for Each $1 Invested

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Results of Exceeding Code for Hurricane Surge

Building new single-family dwellings higher above the base flood elevation (BFE) than the 1-foot required by the 2015 IRC appears to be cost-effective in coastal surge areas identified as V or VE by FEMA in all states. Surge in coastal V-zones is different from riverine flooding, and so its costs and benefits are different.

When the incrementally efficient maximum (IEMax) increase in building height is assessed on a state level, the aggregate BCR (summing benefits and costs over all states) is approximately 7:1, e.g., $7 saved for every $1 spent to build new coastal buildings in V- and VE-zones higher above the shoreline. It would cost approximately $7 million extra to build all new buildings to the IEMax elevation above BFE for one year, and would produce approximately $51 million in benefits.

Table 1 provides BCRs for each natural hazard the project team examined. Figure 1 shows the overall ratio of costs to benefits for the design of new buildings to exceed hurricane-related coastal flooding requirements of the 2015 IRC. The IEMax additional height varies by state, as illustrated in Table 2. The results strongly suggest that greater elevation of new coastal single-family dwellings in V-zones is widely cost-effective. All states have an IEMax building height above code of at least 5 feet. These costs and benefits refer to building new coastal single-family dwellings higher above BFE, not of elevating existing houses. The project team aggregated state and local BCRs to determine the national-level BCR. The costs reflect only the added cost relative to the 2015 IRC.

Mitigation Saves: For Hurricane Surge, Designing to Exceed 2015 Codes Provides $7 Benefit for Each $1 Invested

The stringency of codes adopted at the state and local level varies widely. The project team used the unamended 2015 IBC and IRC as the baseline minimum codes for this study. While minimum codes provide a significant level of safety, society can save more by designing some new buildings to exceed minimum requirements of the 2015 Codes. Where communities have an older code or no code in place, additional costs and benefits will accrue. If all new buildings built the year after were also designed to exceed select I-Code requirements, the benefits would be that much greater, in proportion to the quantity of new buildings.

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Wind	5:1	5:1
Earthquake	3:1	4:1
Wildland-Urban Interface Fire	3:1	4:1

Table 1. Benefit-Cost Ratio by Hazard and Mitigation Measure.

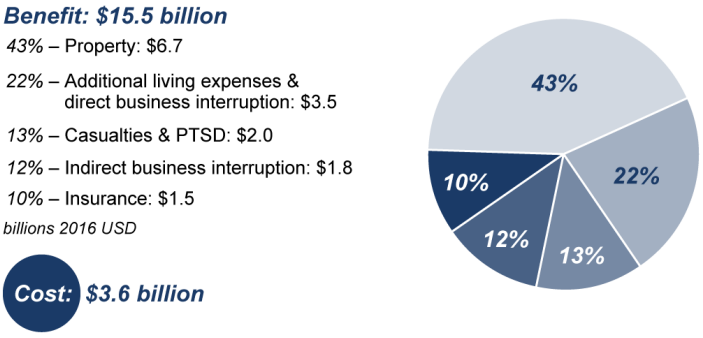

Figure 1. Nationwide benefits by category for designing to exceed 2015 I-Code requirements for flood.

State	First Floor Height above BFE up to IEMax	BCR
Texas	+2 to 8	20.2 to 9.1
Louisiana	+2 to 10	11.3 to 4.8
Mississippi	+2 to 10	27.6 to 10.1
Alabama	+2 to 10	31.1 to 11.7
Florida	+2 to 10	21.1 to 8.4
Georgia	+2 to 6	6.7 to 3.8
South Carolina	+2 to 10	11.8 to 5.0
North Carolina	+2 to 10	12.6 to 5.2
Virginia	+2 to 6	6.7 to 3.8
Delaware	+2 to 6	6.7 to 3.8
Maryland	+2 to 6	6.7 to 3.8
New Jersey	+2 to 6	6.7 to 3.8
New York	+2 to 6	6.7 to 3.8
Connecticut	+2 to 6	6.7 to 3.8
Rhode Island	+2 to 6	6.7 to 3.8
Massachusetts	+2 to 6	6.9 to 3.9
Total		16.9 to 7

Table 2. BCRs for various heights above BFE for new coastal V-zone buildings up to the point where the incremental benefit remains cost-effective.

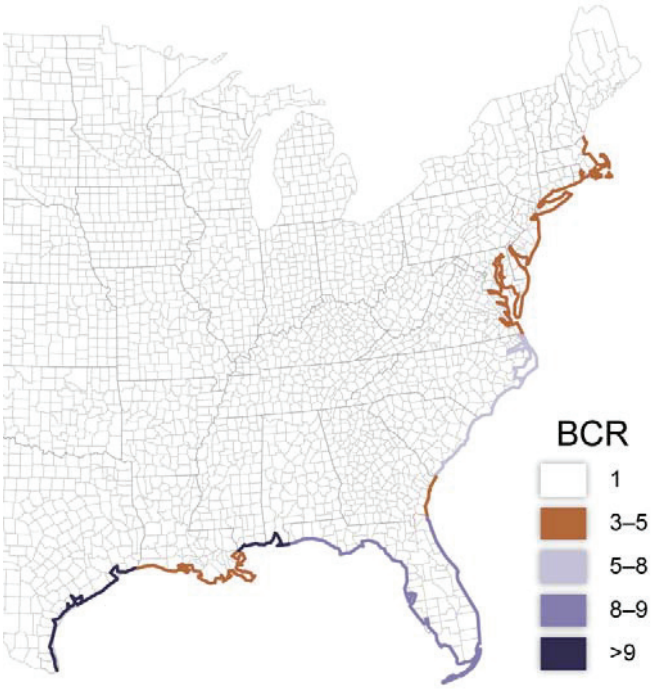

Figure 2: BCR of coastal flooding mitigation by elevating homes above 2015 IRC requirements (by state).

National Institute of BUILDING SCIENCES

Mitigation Saves

For Hurricane Winds, Designing to Exceed 2015 Codes Provides $5 Benefit for Each $1 Invested

Introduction

Natural hazards present significant risks to many communities across the United States. Fortunately, there are measures governments, building owners, developers, tenants and others can take to reduce the impacts of such events. These measures—commonly called mitigation—can result in significant savings in terms of safety, prevent property loss and disruption of day-to-day life.

The National Institute of Building Sciences Multihazard Mitigation Council (MMC) undertook a study in 2017 to update and expand upon the findings of its *2005 Mitigation Saves* study on the value of mitigation. In the 2017 Interim Study, the project team analyzed two areas of mitigation programs:

- **Federal grants:** The impacts of 23 years of federal grants made by the Federal Emergency Management Agency (FEMA), Economic Development Administration (EDA) and the Department of Housing and Urban Development (HUD), resulting in a national benefit of $6 for every $1 invested.
- **Beyond code requirements:** Designing new structures to exceed select provisions of the *2015 International Building Code* (IBC) and *International Residential Code* (IRC) and the adoption of the *2015 International Wildland-Urban Interface Code* (IWUIC). This resulted in a national benefit of $4 for every $1 invested.

Results of Exceeding Code for Hurricane Surge

If all new homes were built to the incrementally efficient maximum (IEMax) Insurance Institute for Business and Home Safety (IBHS) FORTIFIED Home program level for 1 year, it would cost approximately $720 million extra and would produce approximately $3.8 billion in avoided future losses. The aggregate benefit-cost ratio (BCR) (summing benefits and costs over all states) is approximately 5:1, e.g., $5 saved for every $1 spent to build new buildings better along the Gulf and Atlantic Coasts.

Table 1 provides BCRs for each natural hazard the project team examined. Figure 1 shows the overall ratio of costs to benefits for the design of new buildings to exceed hurricane related coastal flooding requirements of the 2015 IRC. Compliance with the IBHS FORTIFIED Home Hurricane program appears to be cost-effective everywhere along the Atlantic and Gulf Coast. The IEMax FORTIFIED level varies by state, as illustrated in Figure 2. The project team aggregated state and local BCRs to determine the national-level BCR. The costs reflect only the added cost relative to the 2015 IRC.

The stringency of codes adopted at the state and local level varies widely. The project team used the unamended 2015 IBC and IRC as the baseline minimum codes for this study. While minimum codes provide a significant level of safety, society can save more by designing some new buildings to exceed minimum requirements of the 2015 Codes. Where communities have an older code or no code in place, additional costs and benefits will accrue. If all new buildings built the year after were also designed to exceed select I-Code requirements, the benefits would be that much greater, in proportion to the quantity of new buildings.

Mitigation Saves:

For Hurricane Winds, Designing to Exceed 2015 Codes Provides $5 Benefit for Each $1 Invested

National Benefit-Cost Ratio Per Peril *BCR numbers in this study have been rounded	Federally Funded	Beyond Code Requirements
Overall Hazard Benefit-Cost Ratio	6:1	4:1
Riverine Flood	7:1	5:1
Hurricane Surge	Too few grants	7:1
Wind	5:1	5:1
Earthquake	3:1	4:1
Wildland-Urban Interface Fire	3:1	4:1

Table 1. Benefit-Cost Ratio by Hazard and Mitigation Measure.

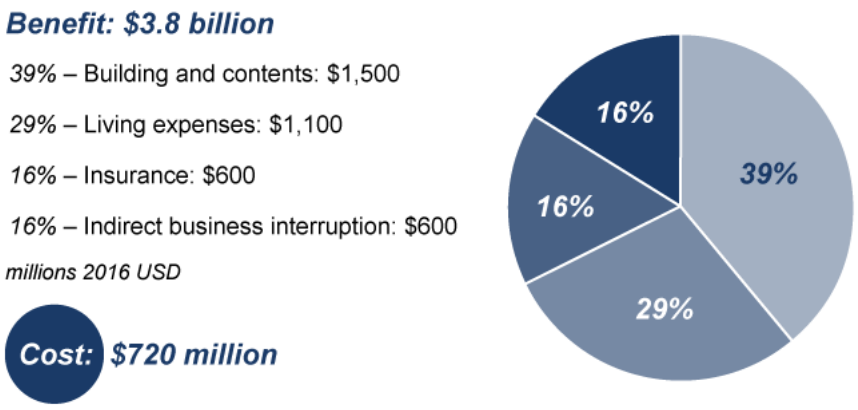

Figure 1. Benefits and costs for 1 year of new construction at the IEMax IBHS FORTIFIED Home Hurricane levels.

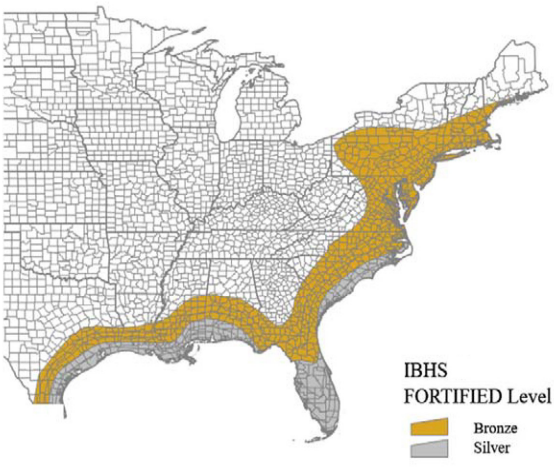

Figure 2. Maximum level of the IBHS FORTIFIED Home Hurricane design for new construction where the incremental benefit remains cost-effective.

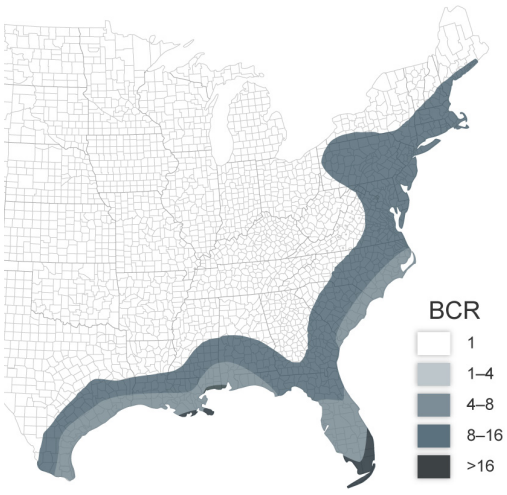

Figure 3: BCR of hurricane wind mitigation by building new homes under the FORTIFIED Home Hurricane Program (by wind band).

National Institute of BUILDING SCIENCES

Mitigation Saves:

For Earthquakes, Designing to Exceed 2015 Codes Provides $4 Benefit for Each $1 Invested

Introduction

Natural hazards present significant risks to many communities across the United States. Fortunately, there are measures governments, building owners, developers, tenants and others can take to reduce the impacts of such events. These measures—commonly called mitigation—can result in significant savings in terms of safety, prevent property loss and disruption of day-to-day life.

The National Institute of Building Sciences Multihazard Mitigation Council (MMC) undertook a study in 2017 to update and expand upon the findings of its *2005 Mitigation Saves* study on the value of mitigation. In the 2017 Interim Study, the project team analyzed two areas of mitigation programs:

- **Federal grants:** The impacts of 23 years of federal grants made by the Federal Emergency Management Agency (FEMA), Economic Development Administration (EDA) and the Department of Housing and Urban Development (HUD), resulting in a national benefit of $6 for every $1 invested.
- **Beyond code requirements:** Designing new structures to exceed select provisions of the *2015 International Building Code* (IBC) and *International Residential Code* (IRC) and the adoption of the *2015 International Wildland-Urban Interface Code* (IWUIC). This resulted in a national benefit of $4 for every $1 invested.

Results of Exceeding Code for Earthquakes

Considering just counties where design to exceed 2015 I-Code requirements for earthquakes has a benefit-cost ratio (BCR) greater than 1.0, if all new buildings were built to their county's incrementally efficient maximum (IEMax) level of strength and stiffness for one year the costs would total approximately $1.2 billion. The sum of the benefits totals approximately $4.3 billion. Therefore, the overall average BCR is approximately 4:1, e.g., an average of $4 saved for every $1 spent to build new buildings stronger and stiffer.

Table 1 provides BCRs for each natural hazard the project team examined. Figure 1 shows the overall ratio of costs to benefits for the design of new buildings to exceed earthquake design requirements of the 2015 IBC. The IEMax strength and stiffness for approximately 2,700 counties (from a BCR perspective) is 1.0, e.g., current code minimum. For approximately 400 counties however, design to exceed 2015 I-Code earthquake requirements appears to be cost-effective. Approximately 40 million people, 13% of the 2010 population of the U.S., live in counties where the IEMax strength and stiffness is twice the code minimum. Another 30 million people—10% of the United States population—live where it would be cost-effective to design to 25% or 50% greater than code-minimum strength and stiffness. The current code makes economic sense on a benefit-cost basis for about three-quarters of the United States population. The IEMax strength and stiffness by county is illustrated in Figure 2. The national-level BCRs aggregate study findings across state and local BCRs. The costs reflect only the added cost relative to the 2015 IBC.

Mitigation Saves:

For Earthquakes, Designing to Exceed 2015 Codes Provides $4 Benefit for Each $1 Invested

The stringency of codes adopted at the state and local level varies widely. The project team used the unamended 2015 IBC and IRC as the baseline minimum codes for this study. While minimum codes provide a significant level of safety, society can save more by designing some new buildings to exceed minimum requirements of the 2015 Codes. Where communities have an older code or no code in place, additional costs and benefits will accrue. If all new buildings built the year after were also designed to exceed select I-Code requirements, the benefits would be that much greater, in proportion to the quantity of new buildings.

National Benefit-Cost Ratio Per Peril *BCR numbers in this study have been rounded	Federally Funded	Beyond Code Requirements
Overall Hazard Benefit-Cost Ratio	6:1	4:1
Riverine Flood	7:1	5:1
Hurricane Surge	Too few grants	7:1
Wind	5:1	5:1
Earthquake	3:1	4:1
Wildland-Urban Interface Fire	3:1	4:1

Table 1. Benefit-Cost Ratio by Hazard and Mitigation Measure.

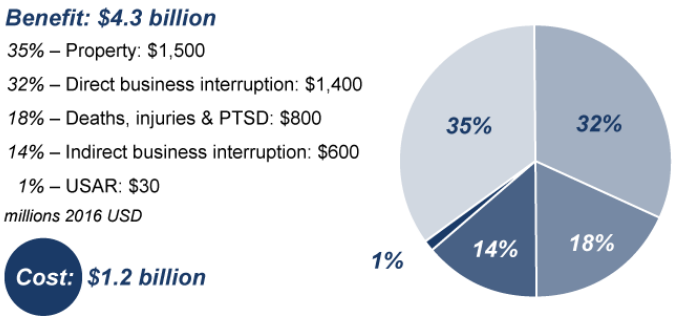

Figure 1. Contribution to benefits from exceeding 2015 I-Code earthquake requirements.

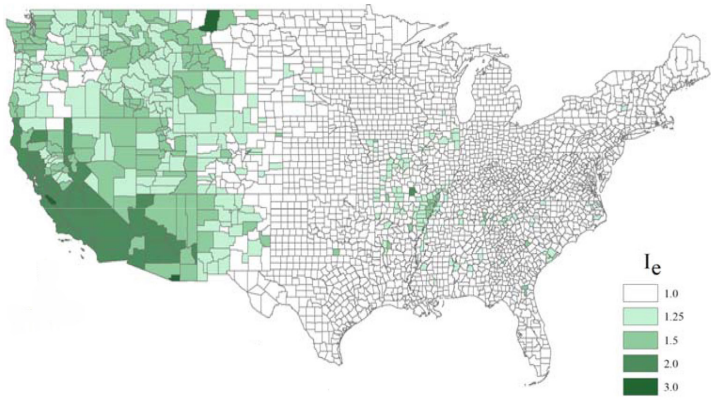

Figure 2. Maximum strength and stiffness factor Ie to exceed 2015 IBC and IRC seismic design requirements where the incremental benefit remains cost-effective.

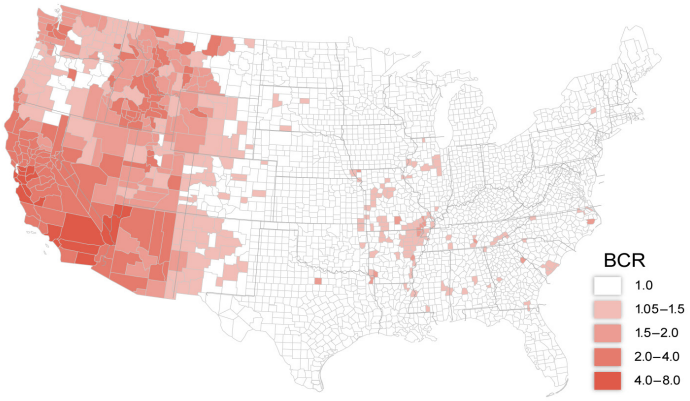

Figure 3. BCR of earthquake mitigation by increasing strength and stiffness in new buildings (by county).

National Institute of BUILDING SCIENCES

Mitigation Saves:

At the Wildland Urban Interface, Complying with the 2015 IWUIC Provides $4 Benefit for Each $1 Invested

Introduction

Natural hazards present significant risks to many communities across the United States. Fortunately, there are measures governments, building owners, developers, tenants and others can take to reduce the impacts of such events. These measures—commonly called mitigation—can result in significant savings in terms of safety, prevent property loss and disruption of day-to-day life.

The National Institute of Building Sciences Multihazard Mitigation Council (MMC) undertook a study in 2017 to update and expand upon the findings of its *2005 Mitigation Saves* study on the value of mitigation. In the 2017 Interim Study, the project team analyzed two areas of mitigation programs:

- **Federal grants:** The impacts of 23 years of federal grants made by the Federal Emergency Management Agency (FEMA), Economic Development Administration (EDA) and the Department of Housing and Urban Development (HUD), resulting in a national benefit of $6 for every $1 invested.
- **Beyond code requirements:** Designing new structures to exceed select provisions of the *2015 International Building Code* (IBC) and *International Residential Code* (IRC) and the adoption of the *2015 International Wildland-Urban Interface Code* (IWUIC). This resulted in a national benefit of $4 for every $1 invested.

Results of Compliance with the IWUIC

If all new buildings built in one year in census blocks with a benefit-cost ratio (BCR) over 1 complied with the 2015 IWUIC, compliance would add about $800 million to total construction cost for that year. The present value of benefits would total approximately $3.0 billion, suggesting a BCR of approximately 4:1, e.g., $4 saved for every $1 of additional construction and maintenance cost.

Table 1 provides BCRs for each natural hazard the project team examined. Figure 1 shows the overall ratio of costs to benefits for the design of new buildings to comply with requirements of the 2015 IWIUC. The BCR only exceeds 1.0 where the fire risk is moderate or higher. Of the 47,870 census blocks, about 10,000 of them (21%) have a BCR greater than 1.0. About 10.5% have BCR > 2.6. About 2% have BCR > 8, and the highest BCR is 15.3. Figure 2 provides the BCR by county. The project team aggregated state and local BCRs to determine the national-level BCR.

If all new buildings built the year after were also designed to meet IWUIC requirements, the benefits would be that much greater, in proportion to the quantity of new buildings.

Mitigation Saves:

At the Wildland Urban Interface, Complying with the 2015 IWUIC Provides $4 Benefit for Each $1 Invested

National Benefit-Cost Ratio Per Peril *BCR numbers in this study have been rounded	Federally Funded	Beyond Code Requirements
Overall Hazard Benefit-Cost Ratio	6:1	4:1
Riverine Flood	7:1	5:1
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Table 1. Benefit-Cost Ratio by Hazard and Mitigation Measure.

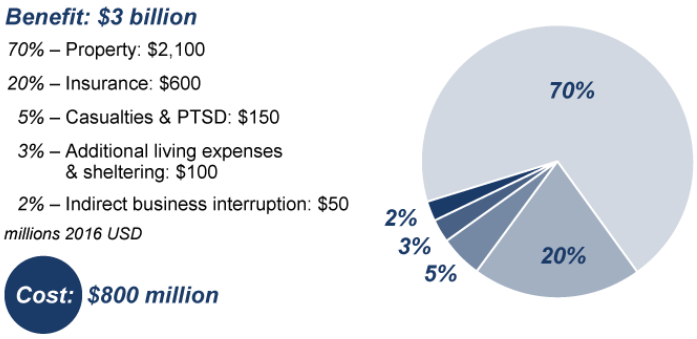

Figure 1. Contribution to benefits from 1 year of compliance with the 2015 IWUIC where it is cost-effective to do so.

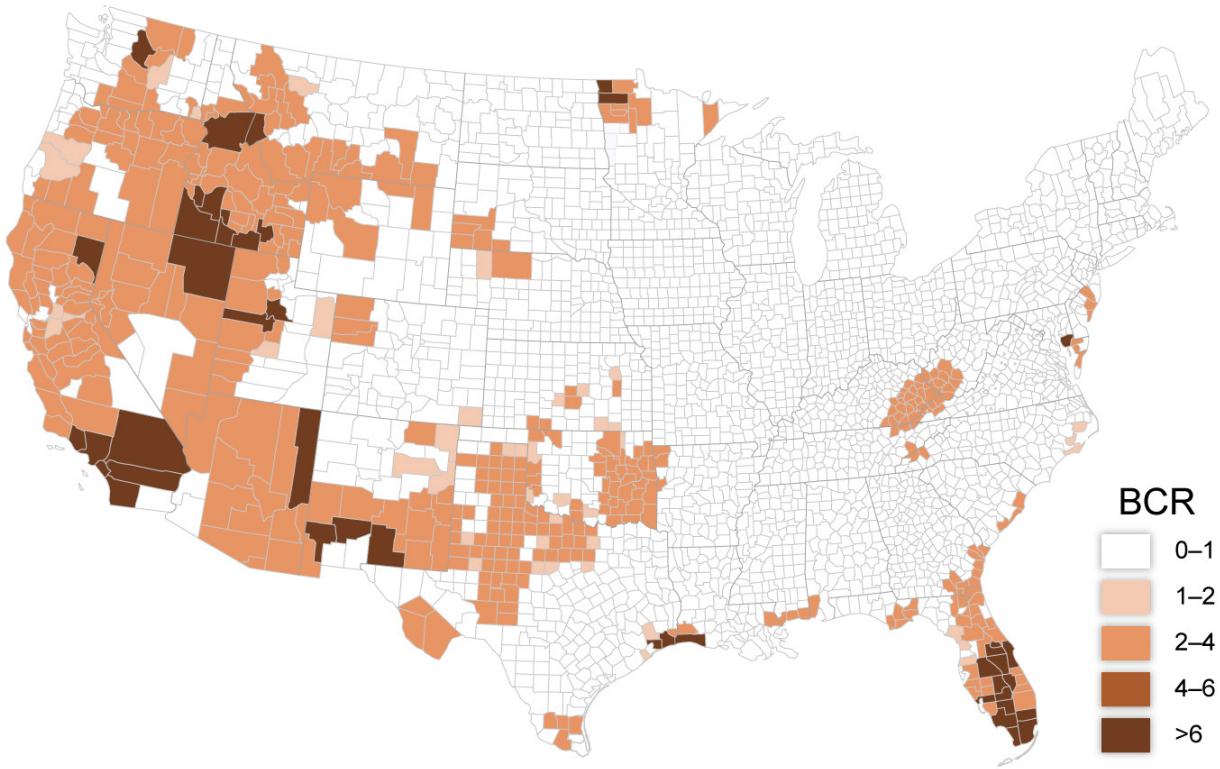

Figure 2. BCR of WUI fire mitigation by implementing the 2015 IWUIC for new buildings (by county).

National Institute of BUILDING SCIENCES

Mitigation Saves:

Mitigation Measures Reduce Injuries & Deaths, Create Jobs

Introduction

Natural hazards present significant risks to many communities across the United States. Fortunately, there are measures governments, building owners, developers, tenants and others can take to reduce the impacts of such events. These measures—commonly called mitigation—can result in significant savings in terms of safety, prevent property loss and disruption of day-to-day life.

The National Institute of Building Sciences Multihazard Mitigation Council (MMC) undertook a study in 2017 to update and expand upon the findings of its *2005 Mitigation Saves* study on the value of mitigation. In the 2017 Interim Study, the project team analyzed two areas of mitigation programs:

- **Federal grants:** The impacts of 23 years of federal grants made by the Federal Emergency Management Agency (FEMA), Economic Development Administration (EDA) and the Department of Housing and Urban Development (HUD), resulting in a national benefit of $6 for every $1 invested.
- **Beyond code requirements:** Designing new structures to exceed select provisions of the *2015 International Building Code* (IBC) and *International Residential Code* (IRC) and the adoption of the *2015 International Wildland-Urban Interface Code* (IWUIC). This resulted in a national benefit of $4 for every $1 invested.

While monetary savings received from implementing mitigation measures to exceed select 2015 code requirements and through federal grants of $4 to $1 and $6 to $1 respectively are significant, people and communities benefit from mitigation in other ways. Disasters disconnect people from friends, schools, work and familiar places. They ruin family photos and heirlooms and alter relationships. Large disasters may cause permanent harm to one's culture and way of life, and greatly impact the most socially and financially marginal people. Disasters may have long-term consequences to the health and collective well-being of those effected. These events often hurt or kill pets and destroy natural ecosystems that are integral parts of communities. The temporary and sometimes permanent shifts of populations after disaster impacts those communities receiving and adapting to an unexpected influx of people.

Injuries, Deaths and Post-Traumatic Stress Disorder Cases Avoided

The project team estimated that just implementing these two segments of mitigation would prevent 600 deaths, 1 million nonfatal injuries and 4,000 cases of post-traumatic stress disorder (PTSD) in the long term.

New design to exceed the 2015 IBC and IRC and to comply with the IWUIC is estimated to prevent approximately 32,000 nonfatal injuries, 20 deaths and 100 cases of PTSD. The past 23 years of federally funded natural hazard mitigation is estimated to prevent deaths, nonfatal injuries and PTSD worth $68 billion, equivalent to approximately 1 million nonfatal injuries, 600 deaths and 4,000 cases of PTSD.

Mitigation Measures Reduce Injuries & Deaths, Create Jobs

The past 23 years of mitigation dominate the estimated savings in deaths, nonfatal injuries and PTSD, compared with 1 year of design to exceed 2015 I-Code requirements, probably because (a) past grants have focused on mitigating the most-risky existing buildings, and (b) current I-Codes do a very good job of protecting life. But both kinds of mitigation do save lives. The benefit-cost ratios (BCRs) presented here already reflect the enhanced life safety using United States government figures of the acceptable cost to avoid future statistical deaths and injuries, but it seems worthwhile to remember that the safety benefits across these mitigation strategies reflect the safety of more than 1 million people and their families who will be able to continue their lives after a natural disaster because foresighted individuals, communities and governments took action and invested money to protect them before disaster struck.

Mitigation Creates Jobs

Designing new buildings to exceed the 2015 IBC and IRC would result in 87,000 new, long-term jobs, and an approximate 1% increase in utilization of domestically produced construction material.[1] The $3.6 billion increase in construction expenses to exceed the selected code provisions for one year would add 1% to current annual construction costs. Across all perils studied (flood, wind, earthquake and wildland-urban interface fire), one can estimate that new design to exceed 2015 I-Code requirements would add approximately 87,000 jobs to the construction-material industry.

National Benefit-Cost Ratio Per Peril *BCR numbers in this study have been rounded	Federally Funded	Beyond Code Requirements
Overall Hazard Benefit-Cost Ratio	6:1	4:1
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Earthquake	3:1	4:1
Wildland-Urban Interface Fire	3:1	4:1

Table 1. Benefit-Cost Ratio by Hazard and Mitigation Measure.

[1]Higher construction costs might also cost jobs if higher costs make new homes less affordable, unless the higher cost of homes is offset by incentives.

National Institute of BUILDING SCIENCES

Mitigation Saves:

Architects Can Present Results to Engage Clients

Introduction

Natural hazards present significant risks to many communities across the United States. Fortunately, there are measures governments, building owners, developers, tenants and others can take to reduce the impacts of such events. These measures—commonly called mitigation—can result in significant savings in terms of safety, prevent property loss and disruption of day-to-day life.

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- **Federal grants:** The impacts of 23 years of federal grants made by the Federal Emergency Management Agency (FEMA), Economic Development Administration (EDA) and the Department of Housing and Urban Development (HUD), resulting in a national benefit of $6 for every $1 invested.
- **Beyond code requirements:** Designing new structures to exceed select provisions of the *2015 International Building Code* (IBC) and *International Residential Code* (IRC) and the adoption of the *2015 International Wildland-Urban Interface Code* (IWUIC). This resulted in a national benefit of $4 for every $1 invested.

Examining the past 23 years of federally funded natural hazard mitigation, the project team found that society will ultimately save $6 for every $1 spent on up-front mitigation cost. The federally funded natural hazard mitigation is estimated to prevent approximately 1 million nonfatal injuries, 600 deaths and 4,000 cases of PTSD. The team also found that if all new buildings were built to the incrementally efficient maximum (IEMax) design to exceed select requirements of the 2015 IBC and IRC and compliance with the 2015 IWUIC for one year, new construction would save approximately $4 in avoided future losses for every $1 spent on additional, up-front construction cost. Such measures are estimated to prevent approximately 32,000 nonfatal injuries, 20 deaths and 100 cases of post-traumatic stress disorder (PTSD).

Architects Can Help Clients, Advance Architectural Practice

Architects serve as trusted advisors for building owners and developers that undertake new construction or major renovations. They can ask key questions during the early phases of the project (programming/pre-design) where implementation of mitigation measures is most cost-effective. They can help clients understand the potential risks associated with a project and determine an owner's risk tolerance and ability to mitigate those risks. While results from the *Interim Report* focus on new construction, future study will provide benefit-cost ratios (BCRs) for select retrofit activities.

Table 1 provides BCRs for each natural hazard the project team examined. The costs reflect only the added costs and benefits relative to the 2015 IBC and IRC. Where communities have an older code or no code in place, additional costs and benefits will accrue. If all new buildings built the year after were also designed to exceed select I-Code requirements, the benefits would be that much greater, in proportion to the quantity of new buildings.

Strategies to exceed minimum requirements of the 2015 Codes studied here include:

- For flood resistance (to address riverine flooding and hurricane surge), build new homes higher above base flood elevation (BFE) than required by the 2015 IBC.
- For resistance to hurricane winds, build new homes to comply with the Insurance Institute for Business & Home Safety (IBHS) FORTIFIED Home Hurricane standards.
- For resistance to earthquakes, build new buildings stronger and stiffer than required by the 2015 IBC.
- For fire resistance in the wildland-urban interface, build new buildings to comply with the 2015 IWUIC.

Findings from the *Interim Report* can provide architects with evidence of the kinds and quantities of mitigation that others have undertaken, the conditions and locations under which those activities appear to be most cost-effective, and the IEMax degree of mitigation. Architects can use the BCR —particularly at a local level—to articulate the value of mitigation to their clients. The ability to look across mitigation strategies and hazards addressed will allow the cost-effective optimization of projects.

Tools like those examined in the *2017 Mitigation Saves* study, including FORTIFIED and the IWUIC, alongside selected provisions to exceed the baseline code, can inform the design process and support discussion on implementing such measures in specific projects.

Architects and allied design professionals play an important role in the development of codes, standards and other guidance developed and implemented at the national and local levels. Results from this *Interim Report* and the ongoing study can inform updates to such guidance. Given their experience and expertise, architects are in an ideal position to translate findings from this study into practical, cost-effective updates and advocate for their adoption.

All Stakeholders Benefit from Mitigation Investments

All major stakeholder groups, including developers, title holders, lenders, tenants and the community, enjoy net benefits from new design to exceed the code requirements the project team studied. All of society wins when designers and builders design and construct new buildings that meet an IEMax level of design exceeding 2015 I-Code requirements where it makes financial sense, on a societal level, to do so. The benefits to tenants and owners only accrue to those who own or occupy buildings designed to exceed 2015 I-Code requirements. However, even those who do not own or occupy those buildings enjoy a share of the community benefits. (Note: This finding reflects long-term averages to broad groups, so it only speaks to the group as a whole, on average, rather than to the experience of each individual member of the group.)

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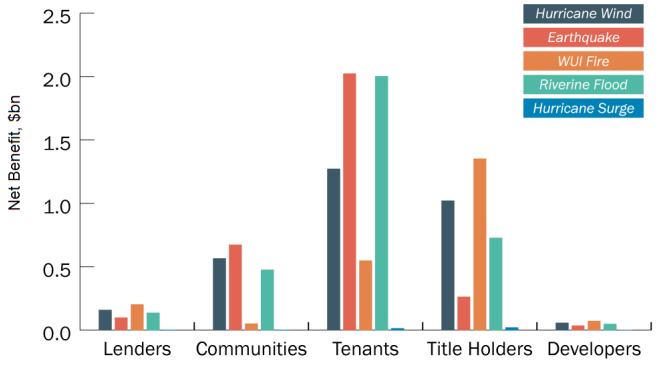

Figure 1. Stakeholder net benefits resulting from one year of constructing all new buildings to exceed select 2015 IBC and IRC requirements or to comply with 2015 IWUIC.

National Institute of BUILDING SCIENCES

Mitigation Saves:

Engineers Can Present Results to Engage Clients

Introduction

Natural hazards present significant risks to many communities across the United States. Fortunately, there are measures governments, building owners, developers, tenants and others can take to reduce the impacts of such events. These measures—commonly called mitigation—can result in significant savings in terms of safety, prevent property loss and disruption of day-to-day life.

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Examining the past 23 years of federally funded natural hazard mitigation, the project team found that society will ultimately save $6 for every $1 spent on up-front mitigation cost. The federally funded natural hazard mitigation is estimated to prevent approximately 1 million nonfatal injuries, 600 deaths and 4,000 cases of PTSD. The team also found that if all new buildings were built to the incrementally efficient maximum (IEMax) design to exceed select requirements of the 2015 IBC and IRC and compliance with the 2015 IWUIC for one year, new construction would save approximately $4 in avoided future losses for every $1 spent on additional, up-front construction cost. Such measures are estimated to prevent approximately 32,000 nonfatal injuries, 20 deaths and 100 cases of post-traumatic stress disorder (PTSD).

Structural Engineers Can Help Clients, Advance Engineering Practice

Engineers provide building owners and developers that undertake new construction or major renovations and other members of the design and construction team with valuable information on opportunities to mitigate risk. They can identify such opportunities and effective solutions during the early phases of the project (programming/pre-design) where implementation of mitigation measures is most cost-effective. They can help clients understand the potential risks associated with a project and determine an owner's risk tolerance and ability to mitigate those risks. While results from the *Interim Report* focus on new construction, future study will provide benefit-cost ratios (BCRs) for select retrofit activities.

Table 1 provides BCRs for each natural hazard the project team examined. The costs reflect only the added costs and benefits relative to the 2015 IBC and IRC. Where communities have an older code or no code in place, additional costs and benefits will accrue. If all new buildings built the year after were also designed to exceed select I-Code requirements, the benefits would be that much greater, in proportion to the quantity of new buildings.

Strategies to exceed minimum requirements of the 2015 Codes studied here include:

- For flood resistance (to address riverine flooding and hurricane surge), build new homes higher above base flood elevation (BFE) than required by the 2015 IBC.
- For resistance to hurricane winds, build new homes to comply with the Insurance Institute for Business & Home Safety (IBHS) FORTIFIED Home Hurricane standards.
- For resistance to earthquakes, build new buildings stronger and stiffer than required by the 2015 IBC.
- For fire resistance in the wildland-urban interface, build new buildings to comply with the 2015 IWUIC.

Findings from the *Interim Report* can provide designers with evidence of the kinds and quantities of mitigation that others have undertaken, the conditions and locations under which those activities appear to be most cost-effective, and the IEMax degree of mitigation. Engineers can use the BCR —particularly at a local level—to articulate the value of mitigation to their clients. The ability to look across mitigation strategies and hazards addressed will allow the cost-effective optimization of projects.

Tools like those examined in the *2017 Mitigation Saves* study, including FORTIFIED, alongside selected provisions to exceed the baseline code, can inform the design process and support discussion on implementing such measures in specific projects.

Structural engineers play an important role in the development of codes, standards and other guidance developed and implemented at the national and local levels. Results from this Interim Report and the ongoing study can inform updates to such guidance. Given their experience and expertise, engineers are in an ideal position to translate findings from this study into practical, cost-effective updates and advocate for their adoption.

All Stakeholders Benefit from Mitigation Investments

All major stakeholder groups, including developers, title holders, lenders, tenants and the community, enjoy net benefits from new design to exceed the code requirements the project team studied. All of society wins when designers and builders design and construct new buildings that meet an IEMax level of design exceeding 2015 I-Code requirements where it makes financial sense, on a societal level, to do so. The benefits to tenants and owners only accrue to those who own or occupy buildings designed to exceed 2015 I-Code requirements. However, even those who do not own or occupy those buildings enjoy a share of the community benefits. (Note: This finding reflects long-term averages to broad groups, so it only speaks to the group as a whole, on average, rather than to the experience of each individual member of the group.)

National Benefit-Cost Ratio Per Peril *BCR numbers in this study have been rounded	Federally Funded	Beyond Code Requirements
Overall Hazard Benefit-Cost Ratio	6:1	4:1
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Table 1. Benefit-Cost Ratio by Hazard and Mitigation Measure.

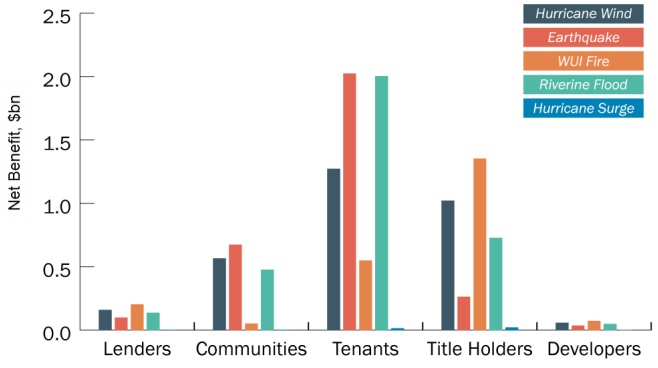

Figure 1. Stakeholder net benefits resulting from one year of constructing all new buildings to exceed select 2015 IBC and IRC requirements or to comply with 2015 IWUIC.

National Institute of BUILDING SCIENCES

Mitigation Saves:

Building Codes Set the Foundation for Mitigation Investments

Introduction

Natural hazards present significant risks to many communities across the United States. Fortunately, there are measures governments, building owners, developers, tenants and others can take to reduce the impacts of such events. These measures—commonly called mitigation—can result in significant savings in terms of safety, prevent property loss and disruption of day-to-day life.

The National Institute of Building Sciences Multihazard Mitigation Council (MMC) undertook a study in 2017 to update and expand upon the findings of its *2005 Mitigation Saves* study on the value of mitigation. In the 2017 Interim Study, the project team analyzed two areas of mitigation programs:

- **Federal grants:** The impacts of 23 years of federal grants made by the Federal Emergency Management Agency (FEMA), Economic Development Administration (EDA) and the Department of Housing and Urban Development (HUD), resulting in a national benefit of $6 for every $1 invested.
- **Beyond code requirements:** Designing new structures to exceed select provisions of the *2015 International Building Code* (IBC) and *International Residential Code* (IRC) and the adoption of the *2015 International Wildland-Urban Interface Code* (IWUIC). This resulted in a national benefit of $4 for every $1 invested.

If all new buildings were built to incrementally efficient maximum (IEMax) design levels to exceed select requirements of the 2015 IBC and IRC and in compliance with the 2015 IWUIC for one year, new construction would save approximately $4 in avoided future losses for every $1 spent on additional, up-front construction cost. Such measures are estimated to prevent approximately 32,000 nonfatal injuries, 20 deaths and 100 cases of post-traumatic stress disorder (PTSD). Examining the past 23 years of federally funded natural hazard mitigation, society will ultimately save $6 for every $1 spent on up-front mitigation cost. The federally funded natural hazard mitigation is estimated to prevent approximately 1 million nonfatal injuries, 600 deaths and 4,000 cases of PTSD.

Codes are the Foundation for Mitigation Investments

Building codes represent the commonly accepted requirements to protect public health, safety and the environment. They address fire, structural integrity, seismology, flood and wind protection, lighting and air quality, energy safety and efficiency, ongoing building maintenance and sanitation. Codes establish requirements for construction quality, safety, energy performance, accessibility and the well-being and comfort of their occupants. Where adopted and adequately enforced, they provide the community and individual building owners and occupants with a high-level of protection from hazard events.

As demonstrated by findings of the *Interim Report* and as will be examined within the ongoing study, there are opportunities to build on this strong foundation. Exceeding select provisions of the 2015 IBC and IRC and implementing the 2015 IWUIC can provide significant benefits. These findings can inform the code development process moving forward. However, some communities have not adopted current building codes and thus are not taking advantage of the mitigation benefits already incorporated into the codes. The benefit-cost ratio (BCR) for this scenario will be examined in the next phase of the *Mitigation Saves* study.

Table 1 provides BCRs for each natural hazard the project team examined. The costs reflect only the added costs and benefits relative to the 2015 editions of the IBC and IRC. Where communities have an older code or no code in place, additional costs and benefits will accrue. If all new buildings built the year after were also designed to exceed select I-Code requirements, the benefits would be that much greater, in proportion to the quantity of new buildings.

Strategies to exceed minimum requirements of the 2015 Codes studied here include:

- For flood resistance (to address riverine flooding and hurricane surge), build new homes higher above base flood elevation (BFE) than required by the 2015 IBC.
- For resistance to hurricane winds, build new homes to comply with the Insurance Institute for Business & Home Safety (IBHS) FORTIFIED Home Hurricane standards.
- For resistance to earthquakes, build new buildings stronger and stiffer than required by the 2015 IBC.
- For fire resistance in the wildland-urban interface, build new buildings to comply with the 2015 IWUIC.

The BCRs and the supporting documentation provided in the *Interim Report* can help inform the ongoing code development process—both at the national and state and local levels. Mayors, city council members, state legislators and code boards can inform discussions on the adoption of updated codes and potential costs and benefits that may accrue to the community and to individual stakeholders.

The very existence of codes provides benefits that are not quantified here, but may be included in the ongoing study. Such benefits include coherence, sensibility and uniformity that leads to consistent specifications and requirements for manufacturers and suppliers, allows for the introduction of innovative systems and helps to ensure building materials perform as intended. Codes are a uniform blueprint for design professionals, builders and inspectors during the project planning and construction process.

Model code development relies on the engagement of an extensive group of diverse stakeholders working together in a consensus-based process to develop, maintain and update model codes intended for state and local implementation. The process combines science and engineering, innovations in technology and materials, economics, industry experience and consumer demand to generate some of the most comprehensive building codes in the world.

All Stakeholders Benefit from Mitigation Investments

All major stakeholder groups, including developers, title holders, lenders, tenants and the community, enjoy net benefits from new design to exceed the code requirements studied. All of society wins when designers and builders design and construct new buildings that meet an IEMax level of design exceeding 2015 I-Code requirements where it makes financial sense, on a societal level, to do so. The benefits to tenants and owners only accrue to those who own or occupy buildings designed to exceed 2015 I-Code requirements. However, even those who do not own or occupy those buildings enjoy a share of the community benefits. (Note: This finding reflects long-term averages to broad groups, so it only speaks to the group as a whole, on average, rather than to the experience of each individual member of the group.)

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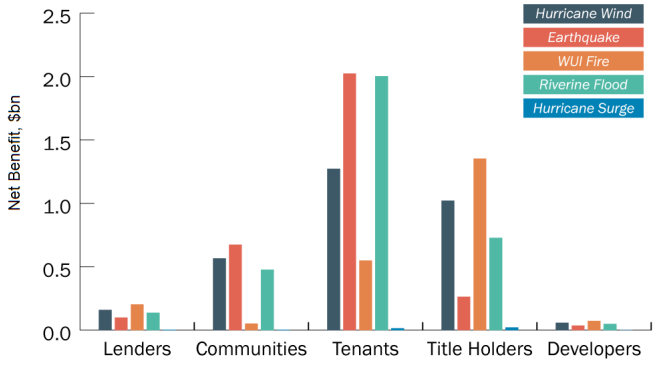

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National Institute of BUILDING SCIENCES

Mitigation Saves:

Results Can Help Educate and Train Decision Makers Responsible for Planning

Introduction

Natural hazards present significant risks to many communities across the United States. Fortunately, there are measures governments, building owners, developers, tenants and others can take to reduce the impacts of such events. These measures—commonly called mitigation—can result in significant savings in terms of safety, prevent property loss and disruption of day-to-day life.

The National Institute of Building Sciences Multihazard Mitigation Council (MMC) undertook a study in 2017 to update and expand upon the findings of its *2005 Mitigation Saves* study on the value of mitigation. In the 2017 Interim Study, the project team analyzed two areas of mitigation programs:

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If all new buildings were built to optimal design to exceed select requirements of the 2015 IBC and IRC and compliance with the 2015 IWUIC for one year, new construction would save approximately $4 in avoided future losses for every $1 spent on additional, up-front construction cost. Such measures are estimated to prevent approximately 32,000 nonfatal injuries, 20 deaths and 100 cases of post-traumatic stress disorder (PTSD). Examining the past 23 years of federally funded natural hazard mitigation, society will ultimately save $6 for every $1 spent on up-front mitigation cost. The federally funded natural hazard mitigation is estimated to prevent approximately 1 million nonfatal injuries, 600 deaths and 4,000 cases of PTSD.

Education and Training of Decision Makers

Decisions made at the local level regarding development, including zoning and building codes, influence a community's susceptibility to hazard events and ultimately its resilience. Policymakers and others charged with making such decisions need education and training that provides credible information regarding the costs and benefits of various mitigation strategies. Organizations like the Natural Hazard Mitigation Association are working with FEMA and the American Bar Association (ABA) to develop disaster risk reduction curriculum.

Through the suite of mitigation measures identified, their associated benefit-cost ratios (BCRs) and the process for arriving at such BCRs, decision makers will have the tools to understand the economic arguments around various development choices and avoid poor decisions that may place undue burdens on the community.

Table 1 provides BCRs for each natural hazard the project team examined. The costs reflect only the added costs and benefits relative to the 2015 IBC and IRC. Where communities have an older code or no code in place, additional costs and benefits will accrue. If all new buildings built the year after were also designed to exceed select I-Code requirements, the benefits would be that much greater, in proportion to the quantity of new buildings.

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- For resistance to earthquakes, build new buildings stronger and stiffer than required by the 2015 IBC.
- For fire resistance in the wildland-urban interface, build new buildings to comply with the 2015 IWUIC.

Public-sector mitigation strategies funded through federal grants include:

- For flood resistance, acquire or demolish flood-prone buildings, especially single-family dwellings, manufactured homes and 2- to 4-family dwellings.
- For wind resistance, add shutters, safe rooms and other common measures.
- For earthquake resistance, strengthen various structural and nonstructural components.
- For fire resistance, replace roofs, manage vegetation to reduce fuels and replace wooden water tanks.

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