URBAN FRAME

URBAN FIRE REGULATORY ASSESSMENT & MITIGATION EVALUATION DIAGNOSTIC

Building Regulation for Resilience Program

WORLD BANK GROUP   GFDRR

1818 H Street NW
Washington DC 20433
Telephone: 202-473-1000
Website: www.worldbank.org

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Back cover: Aerial View of Informal Settlement Fire, South Africa. Photo: Justin Sullivan, 2018.

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Building Regulation for Resilience Program
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ACKNOWLEDGEMENTS

The development of the Urban Fire Regulatory Assessment and Mitigation Evaluation (FRAME) diagnostic was led by Thomas Moullier (Senior Urban Specialist), Keiko Sakoda (Disaster Risk Management Specialist), Brian Meacham (Senior Consultant), and Theresa Abrassart (Urban Development Consultant), with significant inputs from Adam McAllister (Senior Disaster Risk Management Consultant) and Frederick Krimgold (Senior Consultant).

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ACRONYMS

BRCA	Building Regulatory Capacity Assessment
BRR	Building Regulation for Resilience Program
FRAME	(Urban) Fire Regulatory Assessment and Mitigation Evaluation
FSCT	Fire Safety Concepts Tree
GDP	gross domestic product
GIS	geographic information system
GFDRR	Global Facility for Disaster Reduction and Recovery
IBC	International Building Code
ICBO	International Conference of Building Officials (United States)
ICC	International Code Council (United States)
ICT	information communications technology
IFC	International Fire Code (United States)
IFSS CP	International Fire Safety Standards Common Principles
ISO	International Organization for Standardization
LMIC	low- and middle-income countries
NGO	nongovernmental organization
NFPA	National Fire Protection Association (United States)
NIST	National Institute of Standards and Technology (United States)
R2R	Ready to Respond
SDO	Standards Development Organization
TTL	World Bank Task Team Leader
WHO	World Health Organization
WUI	wildland-urban interface

GLOSSARY

Act (of Parliament, for example) indicates high-level legislation passed by the legislative arm of government in a country.

Building codes create legal requirements in the construction process of any infrastructure or building development and must be enforced. Building codes must refer to appropriate consensus (reference) standards. They are promulgated by local or national governments and have independent legal value.

Building fire safety regulatory system is a term that encompasses all regulatory system components that work together to address fire safety in buildings. It includes aspects of the building regulatory framework, fire service regulatory framework, and supporting institutions.

Building regulatory framework is the overarching national framework that determines how a building is to be designed, constructed, and maintained. A building regulatory framework has three core components: a legal and administrative framework, a building code, and building code implementation at the local level. Building regulatory frameworks rely on an ecosystem of supporting institutions and system elements, including the mortgage finance system, frameworks for secure tenure, property and tax regimes, professional societies, and training institutions for the labor force.

Consensus (reference) standards address the performance, quality, design installation, test, and maintenance of all types of materials, systems, and products. Consensus standards are created in the private sector by standards development organizations (SDOs), such as the International Organization for Standardization (ISO), and do not have any particular legal status unless they are adopted by reference into a legislated building code or other regulation. However, if not formally adopted, they still provide an essential reference source as guidance in any building process. Around 4,000 building-related standards exist worldwide.

Chronic risk is a risk distributed over time and space and that could occur at almost any time, such as individual building fires. These risks do not rely on significant precursor events, such as earthquakes or floods, but are a function of conditions as they exist, which may worsen over time.

Compliance documents are the legally binding documents within a building regulatory framework against which compliance with the building code will be assessed. Compliance documents may include the building code itself (e.g., the International Building Code in the United States), specified "deemed-to-comply" documents (e.g., the Approved Documents in England), or codes of practice as promulgated by SDOs (e.g., the Eurocodes for Structural Design).

Design codes (codes of practice) are typically documents produced by SDOs, professional societies, and similar bodies that provide a recommended design approach for specific engineering areas, such as structural design (e.g., Eurocodes for Structural Design, ASCE 7-16, etc.). When such documents are referenced in a building code, and the building code is adopted into law, they become legally enforceable. If not adopted into law, they may still be used as recognized design guidance.

Disaster risk is the potential for significant loss of life, injury, and destroyed or damaged assets that could occur in a system, society, or community in a specific period, often resulting from an extreme event, and can be defined through the combination of three terms: hazard, exposure, and vulnerability.

Exposure is the situation of at-risk people, infrastructure, housing, production capacities, and other tangible human assets located in hazard-prone areas. Measures of exposure can include the number of at-risk people or asset types in an area. These can be combined with the specific vulnerability and capacity of the elements exposed to any particular hazard to estimate the quantitative risks associated with that hazard in the area of interest.

Fire (safety) regulatory framework is the overarching national framework in place that reflects the set of rules, standards, and recommendations intended to prevent, reduce to a minimum the impact of, and provide for response to fire. In some countries, the focus is primarily on response to fire (i.e., the fire service). In other countries, it also includes building and fire safety regulations (e.g., the International Building Code and the International Fire Code in the United States). The framework typically includes consensus standards to support these areas (the National Fire Protection Association (NFPA) in the United States, for example, has developed more than 300 consensus codes and standards aimed at eliminating death, injury, and property and economic loss due to fire, and related hazards).

Hazard is defined by a process, phenomenon, or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption, or environmental degradation. Hazards may be natural, anthropogenic, or socio-natural in origin. Natural hazards are predominantly associated with natural processes and phenomena. Anthropogenic, or human-induced, hazards are induced entirely or predominantly by human activities and choices. Hazards may be single, sequential, or combined in their origin and effects. Each hazard is characterized by its location, intensity or magnitude, frequency, and probability.

Informal building (or informal construction) includes both structures that are built according to national standards, but have not obtained formal planning permission, and semi-permanent structures that do not meet official standards and are most frequently built by low-income households themselves or by landowners for rental. This broad definition of the informal sector means that most of the national housing stock in low- and middle-income countries (LMIC) fits within the informal category.

Land-use regulations are government ordinances and include permits and codes created to ensure that land resources align with national and local policy interests. Regulations are not restricted to controlling existing construction; in large part, they guide future development. Mapping and master plans are essential to land-use regulation, which can be conceived to determine land use at all territorial scales.

Mitigation refers to activities that lessen or minimize the adverse impacts of hazardous events.

Non-engineered construction includes buildings that use traditional building practices with no or very little intervention by qualified architects and engineers in their design.

Policy is a plan or course of action, as of a government, intended to influence and determine decisions, actions, and other matters.

Resilience is the capacity of a system, community, or society exposed to hazards to resist the hazards' effects, adapt to the hazards, or recover from a disaster. For social systems, this is determined by the degree to which they are capable of learning from past disasters and organizing themselves to reduce risk from future hazard events. From a building (engineering) perspective, resilience is commonly defined in terms of the ability of the structure to preserve life safety and continue to function after a hazard event.

Vulnerability defines the conditions determined by physical, social, economic, and environmental factors or processes that increase the susceptibility of an individual, a community, assets, or systems to the impacts of hazards.

OVERVIEW

A Regulatory Diagnostic to Facilitate Fire Risk Reduction in Low- and Middle-Income Countries

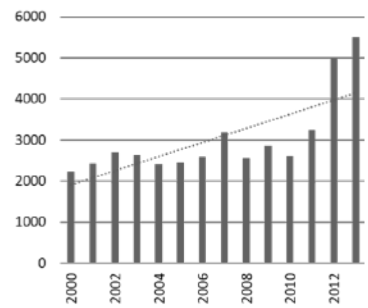
Fires cause up to 180,000 deaths globally per year. This is more than triple the annual average number of fatalities due to all-natural hazards.

More than 180,000 people die from burn-related injuries every year worldwide.[1] In the United States, the annual cost of fire is estimated to be between 1 and 2 percent of GDP, a total of US$328.5 billion in 2014.[2] Over 95 percent of all fire deaths and burn injuries occur in low- and middle-income countries.[3] Populations in urban areas of low- and middle-income countries grow by an estimated 70 million people each year, and low-income countries have seen a 300 percent increase in extent of built-up areas and a 176 percent increase in population over the past 40 years.[4] Reported fire incidents have shown upward trends (see Figure 1) as well. Unregulated, informal settlements are particularly at risk of conflagration and frequent distributed fire incidents.

Rapid urbanization can increase fire risk.

Urbanization is simultaneously a major driver of development, wealth creation, and poverty reduction and one of the most pressing challenges of the 21st century. Between 1990 and 2015, the urban extent occupied by cities in less developed countries increased by a factor of 3.5.[5] By 2050, up to two-thirds of all people will be living in cities.[6]

Figure 1: Reported fire incidents in Ghana



Source: NFPA, 2019.

Figure 2: Informal Settlement Fire in South Africa

Source: Justin Sullivan, 2018

Urbanization can and should be embraced as an opportunity to reduce poverty.[7] However, rapid urbanization can bring with it numerous hazards and risks, including increased fire hazards. This is especially a concern where regulatory capacity is insufficient to implement and enforce comprehensive building fire safety regulations and

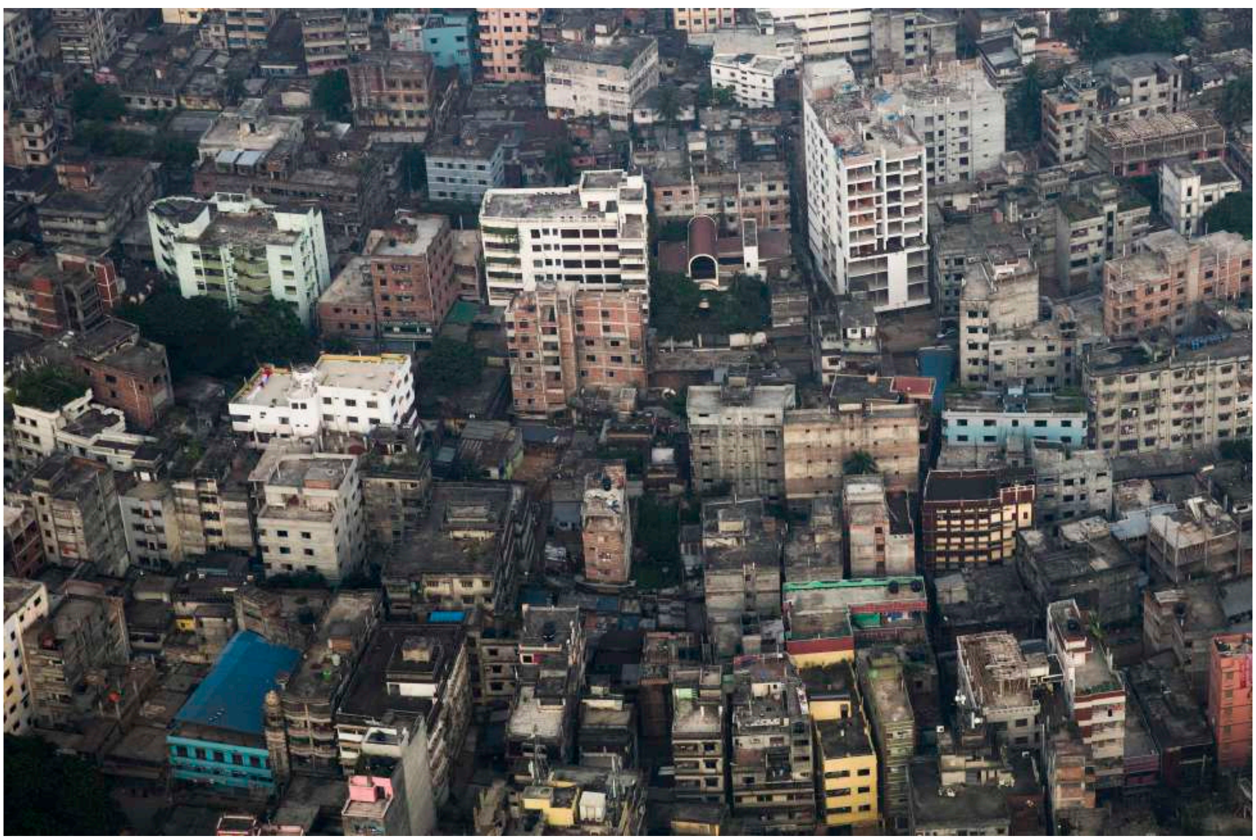
[1] World Health Organization (2018), *Violence and Injury Prevention*, https://www.who.int/violence_injury_prevention/burns/en/.
[2] National Fire Protection Association (2017), *Total Cost of Fire in the United States*, https://www.nfpa.org/News-and-Research/Data-research-and-tools/US-Fire-Problem/Total-cost-of-fire-in-the-United-States .
[3] World Health Organization (2018), *Violence and Injury Prevention*, https://www.who.int/violence_injury_prevention/burns/en/.
[4] UNDRR (2019), *Global Assessment Report on Disaster Risk Reduction*, https://gar.undrr.org/sites/default/files/reports/2019-05/full_gar_report.pdf.
[5] Angel, et al., *Atlas of Urban Expansion—2016 Edition, Volume 2: Block and Roads* (2016) (New York: New York University; Nairobi: UN-Habitat; and Cambridge, MA: Lincoln Institute of Land Policy), https://www.lincolninst.edu/sites/default/files/pubfiles/atlas-of-urban-expansion-2016-volume-2-full.pdf.
[6] https://www.un.org/development/desa/en/news/population/2018-world-urbanization-prospects.html (accessed March 2020).
[7] See, for example, Luc Christiaensen, Joachim De Weerdt, and Yasuyuki Todo (2013), "Urbanization and Poverty Reduction: The Role of Rural Diversification and Secondary Towns" (English), Policy Research Working Paper No. WPS 6422, World Bank, Washington, DC, http://documents.worldbank.org/curated/en/721011468303530295/Urbanization-and-poverty-reduction-the-role-of-rural-diversification-and-secondary-towns; and Mingxing Chen, Yuwen Sui, Weidong Liu, Hui Liu, and Yaohuan Huang (2019), "Urbanization Patterns and Poverty Reduction: A New Perspective to Explore the Countries Along the Belt and Road," *Habitat International* 84: 1–14.

where informal buildings or informal settlements exist and are in widespread use. Positive benefits of urbanization can be realized only if current patterns are significantly transformed to guide urban growth in developing countries toward a more resilient and sustainable trajectory.

The New Urban Agenda[8] agreed upon in Quito in October 2016 conveys a sense of urgency by seeking to harness the transformative force of urbanization and to shape the future of cities. It focuses on four major priorities: national urban policies; more effective municipal finance; territorial planning and design capacity; and laws, institutions, and systems of governance to enhance the rule of law.

Urban fire risk can be heightened during periods of rapid urban development. Inadequate urban planning, infrastructure, and construction practices related to fire prevention and mitigation significantly increase the potential for fire ignition, fire spread, and potential conflagration. Reduction of fire risk requires improved urban planning; infrastructure; building design, construction, and materials; fire suppression capability; and education and training. Proven approaches to fire risk reduction through building and fire regulation include appropriate enabling legislation, well-designed and implemented building and fire regulations, and adequate capacity to undertake building fire safety plan review and construction inspection.

Figure 3: Urban density in Dhaka, Bangladesh



Source: Dominic Chavez/World Bank, 2018.

[8] http://habitat3.org/wp-content/uploads/NUA-English.pdf (accessed March 2020).

Fire safety is one of the foundations of modern building regulation.

Fire safety is historically a cornerstone for building regulation, starting with prevention of conflagration, evolving to address mitigation of fire and explosion hazards associated with the industrial revolution, and presently facilitating innovative construction and safe and accessible buildings. Based on current fire safety science and engineering, a wide range of codes and standards are available to facilitate fire-safe structures and communities. This knowledge and these resources can be adapted to the social, economic, legal, and cultural context of countries at any economic level, including to any currently unregulated informal sector.

Investing in fire resilience aligns with the World Bank vision of eliminating poverty. Is there a way to make these investments financially viable for low- and middle-income countries?

Mitigation of urban fire risks must be a critical consideration for disaster risk reduction and resilient development. Investing in urban disaster risk mitigation and urban resilience is a global priority; significant efforts have been made to put disaster risk management at the forefront of development agendas and local government capacity-building. It is necessary to put urban fire risk at the forefront of development challenges and support the design of comprehensive mitigation strategies that are context-conscious, adaptable, and enforceable.

Investing in building risk reduction measures provides significant economic benefits. For example, according to the U.S. National Institute of Building Sciences, every $1 invested in disaster mitigation results in a saving of $11 through damage and loss reduction.[9]

Fire mitigation investments are proven to be effective in stabilizing and reducing fire losses, thus creating a pathway for sound regulatory frameworks, institutional capacity on risk management, private sector investment, and insurance industry market entry. Tools for assessment and analysis of fire risk must be designed for adaptability to context and recognition of resource limitations. An effective fire risk mitigation strategy requires an interdisciplinary approach that addresses the physical aspects of risk, as well as the social and political challenges that shape policy and financing measures.

Regulatory capacity building provides effective instruments to assess risks and identify opportunities for risk reduction.

The Word Bank Building Regulation for Resilience Program develops and promotes activities to increase regulatory capacity and in turn healthier and safer built environments. Since 2017, the program engages with national authorities and project teams across different regions, and, in close collaboration with a global network of mitigation specialists, it develops reports, assessments, and evaluations and supports initiatives to strengthen code implementation and regulatory policy.

As part of its portfolio of urban resilience diagnostic tools, the Building Regulation for Resilience Program has drawn from expert institutions and researchers to design a fire risk assessment tool for urban settings to evaluate and gauge risk scales, existing legislation, implementation capacity, and feasible mitigation measures. These are articulated as part of a larger process of developing measures to prevent or reduce the likelihood, severity, and consequences of risks in the built environment.

[9] Multihazard Mitigation Council (2018), *Natural Hazard Mitigation Saves: 2018 Interim Report*, https://www.nibs.org/page/mitigationsaves.

The Urban Fire Regulatory Assessment and Mitigation (Urban FRAME) diagnostic supports identifying priority interventions.

The Urban FRAME diagnostic is designed to support government officials and project managers, including World Bank Task Team Leaders, in assessing building fire safety regulatory systems to identify critical gaps and opportunities for building and urban fire risk reduction projects and investment planning.

The Urban FRAME diagnostic focuses on three critical components of the regulatory frameworks for building fire safety: (i) **Legal and Administrative**, (ii) **Development and Maintenance**, and (iii) **Local Implementation**. Because fire safety crosses regulatory regimes — infrastructure and planning, building legislation, and fire legislation — as well as societal capacity building efforts, the diagnostic includes assessment of each area.

The focus on fire risk reduction in the built environment through regulatory frameworks fits into projects to support national and local capacity building; promote legal and regulatory reforms; alleviate the impacts of poverty; and promote health and human capital.

The diagnostic is designed to work with other associated assessments and quantitative analyses, such as the Building Regulation for Resilience Program's Building Regulatory Capacity Assessment (BRCA) and the Emergency Preparedness & Response Program's Ready2Respond Diagnostic.

This document describes:

- Background and context for managing fire risk through regulation, how the Urban FRAME can help, what types and levels of data and information are needed to gauge the effectiveness of the current building fire regulatory measures, and what types of mitigating outcomes could result. (Section 1)
- Why robust building fire regulatory systems are an essential foundation for fire risk reduction, benefiting people, property, and the economy, especially when integrated with managing risks associated with rapid urbanization, natural hazards, climate change, and related societal objectives. (Section 2)
- Different avenues of entry for an Urban FRAME diagnostic through a variety of program sectors. (Section 3)

This document provides:

- A set of questions for collecting basic data and information about the building fire regulatory system components and features currently in place in a target city and/or country, as a first step towards informing fire risk reduction strategies and investment decisions. (Section 4)
- A mechanism to qualitatively summarize the current situation and identify where support may be helpful. (Section 5)

The Urban FRAME diagnostic is designed to facilitate preliminary assessments by government officials and project managers. It provides an opportunity to initiate conversations with stakeholders and other relevant parties on strategies for describing the existing situation and achieving relevant development objectives. It is structured largely in the same way as the Building Regulatory Capacity Assessment (BRCA) diagnostic for compatibility and cross-sharing of data and information.

The Urban FRAME diagnostic recognizes that project managers and equivalent decision-makers may not be experts in building fire safety regulations and support infrastructures. However, collecting the identified data and information will provide an initial baseline for determining the relative completeness of the building fire safety regulatory and infrastructure systems, thereby enhancing project objectives as is or with enhancements in the core areas.

To facilitate additional assistance, Terms of Reference (ToR) for external subject material experts, who can provide helpful expertise in data and information collection and assessment, are provided. (Appendix A)

The Urban FRAME diagnostic can serve as a methodology to draw preliminary findings on the status of the building fire safety regulatory environment. Such findings can be communicated to stakeholders or other relevant parties in the form of a set of recommendations and/or can contribute to the definition of specific project components and activities during the conceptual and design phases of a project.

Overall, the Urban FRAME diagnostic helps to identify critical gaps in fire safety aspects of a building regulatory system and provides the information necessary to develop a baseline for formulating technical assistance to stakeholders, as well as providing useful information for determining areas for improvement and investment.

Source: A large fire ravages Imizamo Yethu in Hout Bay, Aletta Harrison, 2017

1.0 BACKGROUND

1.1 Social and Economic Impacts of Fire

The World Health Organization (WHO) estimates that as many as 180,000 deaths per year may result from burns, many associated with fire, of which 95 percent occur in low- and middle-income countries (LMICs).[10] In addition to those who die, the WHO suggests that millions more are left with lifelong disabilities and disfigurements, often leading to stigma and rejection. However, the exact contribution of fire as a cause of these numbers is difficult to determine.[11] In some countries, data collected by the fire service is used to obtain a more accurate picture. However, many LMICs may lack a national fire service, and/or the fire service may lack resources to collect and publish detailed national fire loss statistics.

Another challenge in LMICs is the presence of informal buildings and informal settlements, which are often prone to rapid fire growth and spread due to the building materials used; high density; use of open-flame cooking and heating devices without safety measures; and narrow roads and paths, which limit access for fire apparatus and egress of people. Fires in such settlements can displace thousands of people, even if casualties are low.[12] An example is the informal settlement fire in Imizamo Yethu, Cape Town, that left 10,000 people homeless.[13] Obtaining an accurate picture of the fire problem is quite difficult.

Figure 4: Fire disaster in Imizamo Yethu informal settlement, Cape Town, South Africa, 2017

Source: Aletta Harrison, 2017.

[10] https://www.who.int/violence_injury_prevention/burns/en/ (website, accessed January 2020).

[11] The WHO estimates are based on the *International Statistical Classification of Diseases and Related Health Problems,* 10th revision (ICD-10). See, for example, US CDC, ICD-10-CM for "exposure, fire": https://icd10cmtool.cdc.gov/?fy=FY2019&q=Exposure%20fire (accessed February 2020).There are several ICD-10 codes for burn-related deaths and injuries caused by electricity; fire, flames; hot gas, liquid, or hot object; radiation; steam; and thermal. There are also numerous codes for fire/flames alone, including inside or outside of a building, different fuel sources (e.g., bed, sofa), smoke inhalation, and more.

[12] See, e.g., lists of informal settlement fires at https://www.iris-fire.com/downloads/media-reports-of-is-fires/ (accessed January 2020), as well as research on fire spread, such as that of S.W. Walls, R. Eksteen, C. Kahanji, and A. Cicione, A. (2019), "Appraisal of Fire Safety Interventions and Strategies for Informal Settlements in South Africa," *Disaster Prevention and Management* 28 (3), www.emeraldinsight.com/0965-3562.htm.

[13] C. Kahanji, R.S. Walls, A. Cicione (2019), Fire Spread Analysis for the 2017 Imizamo Yethu Informal Settlement Conflagration in South Africa," *Int J Disaster Risk Reduct* (April), doi:10.1016/j.ijdrr.2019.101146.

The cost of fire to economies is considerable as well. In the United States alone, the National Fire Protection Association (NFPA) has estimated the total cost of fire in 2014 at US$328.5 billion — 1.9 percent of the U.S. GDP — US$13.2 billion in direct property loss, US$23 billion in insurance, and nearly US$160 billion in facility-related fire safety costs (e.g., construction, fire safety systems, and fire safety management).[14] With a global GDP of about US$85 trillion,[15] if one assumes a global fire costs at 1 percent GDP, that is on the order of US$850 billion per year.

The economic impact of fire in LMICs can be significant as well, not only locally but throughout the global supply chain. Consider, for example, the warehouse fires and collapses in Bangladesh over the last decade. Costs to government, local businesses, and their international trading partners, including the resources expended by the Accord on Fire and Building Safety in Bangladesh (Accord) and the Alliance for Bangladesh Worker Safety (Alliance), have been significant. The cost to local companies for six of the fires alone is estimated at almost US$365 million,[16] without considering associated losses (e.g., human losses, direct and indirect losses in the supply chain, and infrastructure impacts). Across the ready-made garment (RMG) sector as a whole, initial estimates of the cost of remediation alone were some US$929 million, of which US$372 million are associated with electrical and fire issues.[17] Globally, nearly 25 percent of all corporate (commercial) insurance losses are driven by fire/explosion, for a combined approximate value of US $20 billion.

Case Study 1: Bangladesh

The Rana Plaza disaster, Savar, Bangladesh

On April 24, 2013, the fire in and collapse of the Rana Plaza building in Dhaka, Bangladesh, which housed five garment factories, killed at least 1,132 people and injured more than 2,500. The tragedy combined the building's collapse and subsequent fires. This event was preceded by other deadly disasters in garment manufacturing complexes, including the Tazreen Fashion factory fire in 2012, where at least 117 people were confirmed dead in the fire and over 200 were injured. Most recently, on February 2019, a fire that started in a mixed-use building tore through a crowded neighbourhood in Dhaka and killed 70 people. The aftermath of this deadly event had a significant impact on future measures for fire mitigation strategies.

In the aftermath of the Rana Plaza collapse, the government of Bangladesh requested technical assistance for fire risk management. As a component of the Bangladesh Urban Resilience Project, technical assistance is being provided to develop improved fire standards and effective and efficient compliance administration.

Source: ILO (2018), *The Rana Plaza Accident and Its Aftermath, https://www.ilo.org/global/topics/geip/publications/WCMS_632364/lang--en/index.htm*.

[14] J. Zhuang, V.M. Payyappalli, A. Behrendt, and K. Lukasiewicz (2017), "Total Cost of Fire in the United States," Fire Protection Research Foundation, Quincy, MA, USA, https://www.nfpa.org/-/media/Files/News-and-Research/Fire-statistics-and-reports/US-Fire-Problem/RFTotalCost.pdf (accessed January 2020).
[15] https://data.worldbank.org/indicator/NY.GDP.MKTP.CD.
[16] Md. Mizanuzzaman (2016), "Loss and Damage Assessment in the Context of Fire Hazards: A Study on Selected Garment Factories in Bangladesh," *International Journal of Finance and Banking Research* 2 (2): 24–39, doi 10.11648/j.ijfbr.20160202.11.
[17] *Remediation Financing in Bangladesh's Ready-Made Garment Sector: An Overview* (2016), prepared by Emerging Markets Consulting for the International Labour Organization and the International Finance Corporation; copyright © International Labour Organization / International Finance Corporation.

1.2 Rapid Urbanization and Multi-Hazard Impacts

Unfortunately, the incidence, impact, and causes of urban fires in LMIC, particularly in lower-income and informal settlements that are growing rapidly in an urbanizing world, are largely neglected as a policy issue. In part this is due to the lack of reliable data on incidence and impact at both national and local levels, coupled with inadequate financial, material, technical, and human capacities to act to reduce fire risk.[18] The situation is further complicated if governments have yet to develop policies for when they deem informal settlements to be illegal settling of land. The outlook for LMIC is alarming when one considers the coupling there of rapid urbanization, occurring and projected, with frequent and severe fires. History shows that urban fire risk is heightened during periods of rapid development in cities, particularly where combustible construction is widespread.[19] Poor structural standards, limited fire prevention planning, and inadequate response capacity contributed to some of history's most well-known urban fire disasters, including those in London (1666), Chicago (1871), Boston (1872), San Francisco (1906),[20] and Tokyo (1923).[21] Building fire safety regulations enacted over the past 100 years have helped reduce conflagration potential in many higher income countries. Even so, as recently as 1995, fires that followed the Kobe, Japan, earthquake incinerated the equivalent of 70 U.S. city blocks, and the earthquake and fire together destroyed over 150,000 buildings and left about 300,000 people homeless.[22] In many low- and middle-income countries, conflagrations continue, most often in unregulated, informal construction and settlements, as a function of rapid urbanization (including uneven application of regulation).

Figure 5: Overhead view of Wallacedene informal settlement, 2018

Source: Justin Sullivan, 2018.

[18] John Twigg, Nicola Christie, James Haworth, Emmanuel Osuteye, and Artemis Skarlatidou (2017), "Improved Methods for Fire Risk Assessment in Low-Income and Informal Settlements," *Int. J. Environ. Res. Public Health* 14: 139, doi:10.3390/ijerph14020139.

[19] For example, see S.E. Wermiel (2000), *The Fireproof Building: Technology and Public Safety in the Nineteenth-Century American City* (Baltimore, MD: Johns Hopkins University Press); and E. Ben-Joseph (2005),*The Code of the City: Standards and the Hidden Language of Place Making* (Cambridge, MA).

[20] Earthquake in California, Special Report of Maj. Gen. Adolphus W. Greely (1906), extracted from *Annual Reports of the War Department*, vol. I, pp. 91–253 (https://history.army.mil/documents/SFEarthquake/1906Earthquake.htm, accessed March 2020).

[21] T. Usami (2006), "Earthquake Studies and the Earthquake Prediction System in Japan," *Journal of Disaster Research* 1 (3): 416–33.

[22] R.M. Chung, ed. (1996). *January 17, 1995, Hyogoken-Nanbu (Kobe) Earthquake: Performance of Structures, Lifelines, and Fire Protection Systems*, NIST Special Report SP 901, US NIST, Gaithersburg, MD, USA, https://doi.org/10.6028/NIST.SP.901.

Importantly, the San Francisco, Tokyo, and Kobe fires resulted from earthquakes, and in each case, the fire-related losses exceeded the earthquake-related losses; in Tokyo, for example, 80 to 90 percent of the 142,807 fatalities were attributed to fire.[23] The San Francisco fire was a primary motivator for the U.S. insurance industry to lobby for the creation of model building and fire code organizations.[24] One outcome the International Conference of Building Officials (ICBO), established in 1923, which published the first model building code in the United States, the Uniform Building Code (UBC). As urbanization trends continue and new megacities rapidly emerge in developing countries, management of the threat from catastrophic urban fires should be a key consideration for resilient development. This becomes exceptionally important in areas prone to earthquakes and flooding, especially where combustible building materials are permitted, open-flame cooking or lighting may be used, and electricity infrastructure is inadequate, as the combined effect of fires following earthquakes and floods has been proved to be devastating (see additional discussion in Section 2).

1.3 Lack of Robust Building Fire Safety Regulatory Systems

Unfortunately, many LMICs and their urban centers lack robust regulatory systems and supporting infrastructure for building fire mitigation. While this is true for formal and informal buildings, the impacts are often most significant where informal or poor construction exists. Fires in informal settlements and inadequately constructed, protected, and maintained formal construction throughout South and Central America, Africa, and Asia highlight these concerns.

Case Study 2: The Philippines

Fires in Informal Settlements Across the Philippines

The Bureau of Fire Protection reported that between January and June 2018, more than 2,200 fires occurred in Manila. The majority of fires reported in the Philippines were in informal settlements inhabited by highly vulnerable populations. The Philippines is chronically subject to destructive fires: in October 2019, a fire in the Manila Cruz district left more than 200 families homeless. In January 2017, a fire left more than 1,200 families homeless in the Manila Navotas suburb, and the following month, in February 2017, a fire left more than 15,000 homeless in the capital's San Lazaro district. In March 2015, a fire in the Parola Compound, near Manila's main port, left 7,000 families homeless. On February 15, 2011, a fire in one of the capital's largest informal settlements, Bahay Toro, left more than 10,000 people homeless; a week earlier a fire had destroyed 600 homes in suburban Quezon City, leaving 20,000 homeless.

Sources: Guardian (2018), "Firefighting in Manila's Tinderbox Slums," https://www.theguardian.com/world/2018/jun/25/firefighting-in-manila-tinderbox-slums-a-picture-essay; *New York Times* (2017), "Fire Tears Through Manila Slum, Leaving 15,000 Homeless," https://www.nytimes.com/2017/02/08/world/asia/fire-tears-through-manila-slum-leaving-15000-homeless.html.

[23] T. Usami (2006), "Earthquake Studies and the Earthquake Prediction System in Japan," *Journal of Disaster Research* 1 (3): 416–33.

[24] C.H. Geschwind (2001), *California Earthquakes: Science, Risk and the Politics of Hazard Mitigation* (Baltimore, MD: Johns Hopkins University Press).

Benefits of robust building regulatory systems and supporting institutions, and what is needed to achieve them, were identified in the Building Regulations for Resilience (BRR) report.[25] To help guide pragmatic and programmatic investments, the Building Regulatory Capacity Assessment (BRCA)[26] was developed to collect data on the existing situation in LMICs in these core areas: Legal and Administrative (i.e., acts, legislation), Development and Maintenance (e.g., planning and zoning codes, building codes, etc.), Implementation (including resources), and Supporting Institutions. The BRCA focuses on the capacity in each of these areas with respect to achieving a robust building regulatory system.

Figure 6: Elements of a robust building regulatory system

Source: World Bank (2017), Building Regulatory Capacity Assessment, Level 2.

[25] *Building Regulation for Resilience* (2015), ©2015 International Bank for Reconstruction and Development/International Development Association, https://www.gfdrr.org/sites/default/files/publication/BRR%20report.pdf.

[26] *Building Regulatory Capacity Assessment, Level 1* (2017), © 2017 International Bank for Reconstruction and Development, https://www.gfdrr.org/sites/default/files/publication/building-regulatory-capacity-assessment-level-1-2017.pdf, and *Building Regulatory Capacity Assessment, Level 2* (2017), © 2017 International Bank for Reconstruction and Development, https://www.gfdrr.org/sites/default/files/publication/building-regulatory-capacity-assessment-level-2-2017.pdf.

Figure 6 shows the BRCA themes rearranged to illustrate areas of potential investment for capacity building within the legal framework and supporting institutions (government, industry, owners, and other actors). The BCRA diagnostic uses a set of directed questions to gather baseline data and information. However, it does not explore in detail the building fire hazard and risk challenges and associated opportunities that can be realized through a robust building regulatory system. The Urban Fire Regulatory Assessment and Mitigation Evaluation (Urban FRAME) diagnostic focuses on this important issue

1.4 The Urban Fire Regulatory Assessment and Mitigation Evaluation (Urban FRAME) Concept

The Urban FRAME diagnostic was developed to achieve several goals. It facilitates the collection of critical information about the regulatory framework for building fire safety in a particular jurisdiction and helps to identify where critical gaps exist. It develops a baseline for formulating enhancements to administrative, technical, regulatory maintenance, and implementation aspects of fire safety components of building and fire regulatory systems. It identifies needs and facilitates education and training opportunities to enhance the fire resilience of buildings, neighborhoods, and cities.

Like the BRCA, the Urban FRAME diagnostic focuses on assessment of the capacity within the legal and regulatory framework, and the capacity of supporting institutions and actors (e.g., government agencies, industry, building owners, academia, community groups, NGOs) in facilitating a robust building fire safety regulatory system. A strong relationship exists between the fundamental building regulatory system components of a jurisdiction, addressed by the BRCA diagnostic, and the building fire safety regulatory components, considered by the Urban FRAME. This is illustrated in Figure 7, which more completely illustrates the interaction of the BRCA and Urban FRAME components. The diagram shows how the BRCA and the Urban FRAME analytical tools help to inform investment activities within the building regulatory framework as well as structural interventions which complement each other.

Figure 7: Relationship between the BRCA and the Urban FRAME diagnostic

BRR Investment Activities

Investment Programs & Platforms

LEGAL AND REGULATORY FRAMEWORK

Establishes core building lifecycle quality control and assurance mechanisms in line with international good practice.

GOVERNMENT, INDUSTRY & OWNERS' CAPACITY

Develops capacity and skills of public and private sector stakeholders to promote a resilient built environment.

BUILDING INFRASTRUCTURE & RESILIENCE

Improves structural resilience of building, infrastructure and service facilities.

Building Regulatory Capacity Assessment (BRCA)

Investment Activities

Legal and Regulatory Framework:

- Legal, policy and regulatory reforms
- Building code, standards and guidelines
- Building approval process
- ICT infrastructure and software for digitalization of building permit process
- Building inspection mechanism
- On-site & remote inspection
- Standards for construction materials and methods
- Laboratory & testing equipment
- Accreditation of building products, labs and professional organizations

Government, Industry & Owners' Capacity:

- Capacity building for planning and construction regulators
- Capacity building for private building professionals
- Training of builders and construction workers
- Professional certification
- Building rating systems
- Partnership with other contributors to building safety (i.e. insurance, banking sector)

Building Infrastructure & Resilience:

- Building vulnerability assessment
- Retrofit of critical buildings (schools, hospitals, government buildings)
- Retrofit of critical infrastructure
- Subsidy program for building quality improvement and retrofitting

Urban Fire Regulatory Assessment and Mitigation Evaluation (Urban FRAME)

Investment Activities

Legal and Regulatory Framework:

- Fire safety legislation
- Fire-safe urban and land use planning
- Fire safety regulatory provisions and standards
- Fire safety review and inspection
- Fire laboratory and testing equipment

Government, Industry & Owners' Capacity:

- Capacity building for fire review and inspection
- Capacity building for fire safety design and engineering professionals
- Capacity building for tradespersons and skilled labourers
- Fire safety engineering academic program
- Appropriate fire safety technologies
- Community outreach and public education
- Fire insurance

Building Infrastructure & Resilience:

- Fire vulnerability assessment
- Fire apparatus access infrastructure
- Fire suppression water resource and infrasructure
- Neighborhood fire resiliency upgrading
- Fire safe electricity infrastructure
- Building fire safety system upgrades (i.e., fire sprinklers, fire resistant materials, smoke alarms, fire extinguishers)
- Fire safe home appliances (i.e., heating and cooking appliances, electrical systems)

Legend

- Construction Permit Diagnostic (BRR Tool) — marks: Building approval process
- Training Needs Assessment (BRR Tool) — marks: Capacity building for planning and construction regulators
- Works and Equipment — marks: ICT infrastructure and software for digitalization of building permit process; On-site & remote inspection; Laboratory & testing equipment; Fire apparatus access infrastructure; Fire suppression water resource and infrasructure; Fire safe electricity infrastructure; Building fire safety system upgrades; Fire safe home appliances

Table 1 below illustrates where data and information to support the Urban FRAME may be found. A more extensive list of these areas of exploration is provided in Section 1.5 below.

Table 1: Intersection of regulatory system components and Urban FRAME themes

		FUNDAMENTAL REGULATORY SYSTEM COMPONENTS			
		Legal and Administrative	**Development and Maintenance**	**Implementation**	**Supporting Institutions**
URBAN FRAME THEMES	**Building Fire Safety Regulatory Capacity**	• Building acts and legislation	• Building codes/ regulations • Material/design/ test/installation standards • Fire protection/ safety system provisions • Fire protection system design/test/installation standards	• Building dept capacity — plan review, inspection, approvals • Building dept operational resources • Private sector plan review, inspections, approvals • Testing and certification	• Relevant education and training • Qualification system(s) for professionals and trades • Insurance
	Fire Prevention Regulatory Capacity	• Fire Service acts and legislation	• Fire prevention codes/regulations • Fire protection/ safety system provisions • Fire protection system inspection standards • Fire incident data and reporting requirements	• Fire dept. capacity — prevention • Plan review, site inspection, resources, etc. • Fire data collection • Education and training • Fire dept. capacity — suppression • Operational fire-fighters, apparatus, fire stations, etc. • Testing and certification	• Relevant education and training • Qualification system(s) for professionals and trades • Insurance
	Fire Safety Planning and Infrastructure Capacity	• Planning acts and legislation	• Planning and zoning regulations (number of buildings, density of buildings, etc.) • Vehicle access and transportation regulations	• Building separation • • Roads for fire apparatus and escape • Fire suppression water	• Land valuation mechanisms • Tenure frameworks • Public-private partnerships • Insurance
	Societal Capacity (Government, Industry, Owners, and Public)	• Public health and safety acts / legislation • Census data acts / legislation • Professional services legislation (architect/engineer) • Builder licensing legislation • Skilled trades licensing legislation (carpenter, mason)	• Community support regulations or ordinances • Public health and safety regulations • Census data collection and availability regulation	• Social services • Health services • Financial assistance services • Census and demographic data	• Academia • Community and home fire safety education and training • Community and home fire protection devices • NGO support (e.g., Red Cross) • Community support networks • Microfinancing • Insurance

1.5 Data and Information Collection

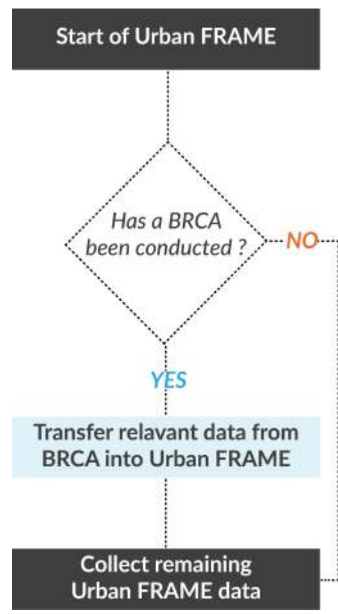
The primary aim of the Urban FRAME diagnostic is information (data) gathering: the collection of baseline information to understand the current status of the building fire safety regulatory system in the city or country of concern. For World Bank projects, the Urban FRAME process starts with a determination of what data may be available from prior assessments by the Bank and its contractors, in particular, the BRCA. Non-Bank projects may have various potential starting points, as outlined below and in Section 4.

If a BRCA has been undertaken, basic data regarding the building and planning regulatory system may exist. In some cases, this may include information about the building fire regulatory system as well. However, since several countries have separate systems for building and fire regulation — from the relevant ministries / agencies and acts at the top level on downward — a complete picture of the building fire safety legislation and regulatory system may be lacking.

If pertinent data and information exist from a previously conducted BRCA, those are transferred over to the Urban FRAME diagnostic. If a BRCA diagnostic has not been conducted, all pertinent information will need to be gathered via the Urban FRAME diagnostic, as illustrated in Figure 8.

While it is recognized that some aspects of fire risk and vulnerability are building or structure specific, the focus of the Urban FRAME is on fire risk reduction that can be achieved at the regulatory infrastructure level (i.e., the city- or nationwide building regulatory system), not the individual building or person level per se (i.e., not building-specific design solutions).

Figure 8: Data collection process overview



As a regulatory-level fire risk reduction tool, the types of information and data to be targeted and assessed include:

1. Building fire safety and fire prevention regulatory system data
    a. Legal and administration (i.e., enabling acts, building legislation, fire legislation, etc.)
    b. Development and maintenance (i.e., building fire safety regulations, fire prevention regulations, development processes, change processes, etc.)
    c. Implementation (i.e., review and enforcement capacity, training, education, etc.)
2. Demographic, socioeconomic, and vulnerability data (i.e., overall population, percentage of vulnerable populations (very young, very old, disabilities, etc.; income or poverty level; etc.): numbers, geographical location, distribution
3. Incidence and consequence data
    a. Fire-related injury and casualty data (overall, by population groups, by geographic area, etc.)
    b. Number of displaced or homeless persons resulting from fire
    c. Physical fire loss data, including accurate geographic location (i.e., number of structure fires, location, extent of burning, direct property losses, etc.)
    d. Urban conflagration (formal and informal buildings), wildland fire and wildland-urban interface (WUI) data (i.e., large open fires: location, extent, structures involved)
4. Formal and informal buildings data (e.g., location, extent, type of construction, building footprints, building materials, fuel loads, wall linings, and location of openings)
5. Response infrastructure data
    a. Fire service data (e.g., firefighters, stations, equipment)
    b. Firefighting water and infrastructure availability
    c. Vehicular access data (e.g., street widths)

Specific diagnostic questions associated with the above are presented in Section 4. When collecting data and information, it is important to recognize that building fire safety requirements may exist under two entirely different regulatory structures — building and planning acts and legislation, and fire service acts and legislation — which may in turn fall under the purview of different ministries or departments. To obtain a complete picture, both avenues must be interrogated. Also, it should be recognized that some LMICs will not have complete or necessarily reliable data for many of the desired data points outlined above and detailed in Section 4. However, whatever data and information are available should be collected.

With respect to the data and information, building fire safety regulatory data (1) will be a matter of fact: it exists, or it does not, and, if it does, what aspects are included. Demographic data (2) are assumed to be collected by government (census), at least for population numbers and locations of formal construction. Given that informal settlements can change very rapidly, it is understood that demographic data in these environments may be difficult to obtain, and the frequency of updates will be important to consider. Fire-related death and injury data (3a) may be reported and estimated locally or nationally, and it may be reported to the World Health Organization (WHO). In the latter case, this data can provide a starting point, even where the fire service cannot provide any. It is anticipated that some level of fire incident data is collected (3b, c, d), but this will be known from initial questioning (Section 4). It is anticipated that the country or city will have data on the location and percentage of formal construction as well as some sense of the location and percentage or informal buildings (4). Finally, it is expected that basic information on fire service capacity (5) will be available in most locations. Where data are not available for items 1 through 5, missing areas can be considered investment opportunities for data collection for fire risk reduction.

1.6 Types of Regulatory-System-Focused Fire Risk Reduction and Mitigation Strategies

Once data are collected, it is possible to identify potential fire risk reduction mechanisms. Various types of regulatory-system-focused fire risk mitigation strategies exist, as outlined below.

1. Increasing the national- and/or city-level building fire safety regulatory system capacity

a. Creating or enhancing enabling legislation related to building fire safety
b. Enhancing building regulation/code provisions for fire risk mitigation through:
    i. Engaging knowledgeable persons in regulatory development
    ii. Facilitating broad stakeholder representation in regulatory development
c. Providing reference to nationally and/or internationally recognized consensus standards, such as for:
    i. Fire performance of construction materials
    ii. Fire protection systems design, installation, testing, and maintenance
    iii. Fire engineering design guidance
d. Enhancing building fire safety design review, approval, and enforcement capacity, such as through:
    i. Building department resources
    ii. Fire prevention resources
    iii. Education and training
e. Providing for national fire testing capacity for building materials and products
f. Providing for national testing/accreditation capacity for fire performance of materials and for fire safety system and component performance
g. Enhancing capacity in fire safety engineering/design through such means as educational offerings (university and professional development), training programs, qualifications schemes, competency assessment
h. Enhancing fire protection systems technician/installer/maintainer capacity through such means as educational offerings, training programs, qualifications schemes, competency assessment
i. Advancing fire data and technology, such as through new or enhanced data collection systems, integration of remote sensing capabilities, possible use of new technology (such as data collection through smartphones, GIS, and remote sensing technology)

2. Increasing the national- and/or city-level fire prevention regulatory system capacity

j. Creating or enhancing enabling legislation related to fire prevention, fire service, and emergency response
k. Enhancing fire prevention regulation/code provisions for building fire risk mitigation through:
    i. Engaging knowledgeable persons in regulatory development
    ii. Facilitating broad stakeholder representation in regulatory development
l. Enhancing fire prevention enforcement capacity (i.e., for plan reviews, site inspections, existing building audits) through such mean as:
    i. Enhancing fire prevention department resources
    ii. Enhancing education and training resources
m. Enhancing national fire service training facilities and capabilities

3. Increasing fire-safe urban planning and critical infrastructure capacity

n. Enabling and/or enhancing fire-safe urban planning legislation and regulation as related to street layout and street width for firefighting vehicle access, lot size, building setback, building separation, fire service site access, appropriate egress pathways, wildland-urban distancing and protection, and related components in:
    i. Formal construction areas, including designation fire districts/zones
    ii. Informal construction areas
    iii. Mixed formal and informal construction areas
    iv. At the urban-wildland fire interface (WUI)

o. Increasing fire resiliency and affordability of informal construction:
    i. Facilitating use or provision of non- or limited combustible building materials
    ii. Facilitating use or provision of safer heating and lighting technology
    iii. Provision of fire extinguishers, smoke alarms, etc.
    iv. Facilitating systematic engineering-based solutions for informal construction

p. Facilitating or enhancing firefighting water capacity and distribution through such means as:
    i. Provision of or enhancement to firefighting water mains systems
    ii. Expansion of hydrant locations
    iii. Provision of or enhancement to water storage location and capacity
    iv. Provision or facilitation of alternative means of fire control (e.g., motorbikes with small pumps, bucket brigades, local firefighting stations within settlements to act as first suppression teams before the fire brigades arrive, etc.)

4. Increasing societal capacity (government, industry, owners, and public)

q. Developing or enhancing communications strategies targeting different stakeholders:
    i. Residents of formal and informal communities
    ii. Vulnerable population groups in each community (e.g., young, elderly, disabled, low/no income, etc.)
    iii. Financial institutions or alternative financing strategies
    iv. Industry professionals, including masons and trades, building practitioners, and building owners

r. Exploring potential partnerships with community groups, specialized NGOs, academia, and others to develop and deliver appropriate and training:
    i. Development of home and community programs (e.g., home safety planning, fire extinguishers, fire alarms, informal or formal community alarm systems, community fire control programs, etc.)
    ii. Working with NFPA on public service messaging such as "Learn Not to Burn," "Stop, Drop and Roll," etc.
    iii. Working with professional societies for fire safe design training and education

s. Defining key messages and communications solutions to demonstrate the benefits of fire safety practices for safe building and to support broader community-wide commitment to safer building practices, with a focus on the informal or unregulated sector

t. Supporting the community in preparing guides, brochures, or other forms of informational and promotional materials
u. Preparing and submitting a schedule of meetings and seminars
v. Considering alternative financing schemes (e.g., insurance schemes with micro- or community-based financing)

Other types of risk reduction strategies may be feasible as well, depending on the specific situation in a city or country.

2.0 WHY ROBUST BUILDING FIRE REGULATORY SYSTEMS ARE IMPORTANT

Fire is a chronic risk that plagues all countries. Robust building fire safety regulatory systems are needed to help address a wide range of issues, including:

- Facilitating fire risk mitigation measures during periods of rapid urbanization
- Establishing minimum standards for life safety in case of fire
- Establishing minimum standards for protection of property in case of fire
- Establishing minimum standards for limiting the potential for urban conflagration
- Addressing post-event fire as part of multi-hazard mitigation measures
- Helping to reduce impacts on the climate from fire events and increasing climate change resilience
- Helping to reduce economic impacts of fire

2.1 Facilitating Fire Risk Mitigation Measures During Periods of Rapid Urbanization

High-income countries, such as the United Kingdom, Japan, and the United States, have all experienced devastating fires during periods of urbanization. Inadequate building regulation and construction oversight, inadequate urban planning, overcrowding, lack of uniform test and equipment standards, limited fire prevention planning and infrastructure, and inadequate response capacity contributed to some of history's most well-known urban fire disasters,[27] including those in London (1666), Chicago (1871), Boston (1872), San Francisco (1906), and Tokyo (1923).

The risks can increase when the urban centers are prone to multiple hazard events. Fires following earthquakes, for example, have proven to be catastrophic during periods of urban growth, as well as in stable urban environments, when combinations of combustible and noncombustible building materials are used without adequate urban planning and fire suppression infrastructure. This occurred in San Francisco in 1906,[28] Tokyo in 1923,[29] and as recently as 1995 in Kobe. In Kobe, an earthquake resulted in more than 6,000 deaths and 30,000 injuries, but the fires that followed incinerated the equivalent of 70 U.S. city blocks; taken together, the fire and earthquake destroyed over 150,000 buildings and left about 300,000 people homeless.[30]

The situation becomes even more challenging when considering the wide range of vulnerable populations in urban areas, including the urban poor, who may be crowded into formal or informal buildings; the growing number of disabled within the population; and the rapidly aging population. If concepts such as accessible means of access and egress are not provided through building regulatory systems, they may be absent in constructed buildings.

The urban fire risk concern is more acute within rapidly developing urban areas of LMICs. This is particularly true for high density areas, such as informal settlements or markets, where application and enforcement of formal building and fire safety regulations may be limited, electrical installations

[27] For example, see, S.E. Wermiel (2000), *The Fireproof Building: Technology and Public Safety in the Nineteenth-Century American City* (Baltimore, MD: Johns Hopkins University Press); and E. Ben-Joseph (2005),*The Code of the City: Standards and the Hidden Language of Place Making* (Cambridge, MA, USA).
[28] C.H. Geschwind (2001), *California Earthquakes: Science, Risk and the Politics of Hazard Mitigation* (Baltimore, MD: Johns Hopkins University Press).
[29] T. Usami (2006), "Earthquake Studies and the Earthquake Prediction System in Japan," *Journal of Disaster Research* 1 (3): 416–33.
[30] R.M. Chung, ed. (1996), *January 17, 1995 Hyogoken-Nanbu (Kobe) Earthquake: Performance of Structures, Lifelines, and Fire Protection Systems*, NIST Special Report SP 901, US NIST, Gaithersburg, MD, USA, https://doi.org/10.6028/NIST.SP.901.

may be inadequately protected, and open flames may be used for cooking and lighting.[31] With the combination of combustible construction, potentially high dwelling densities, inhabitants storing materials in and around homes, and poor construction materials and techniques, conflagrations can become large, behaving in ways more akin to that of wildland fires (due to the distributed fuel load represented by combustible construction, accompanied by very permeable structures), rather than typical structural compartment fires.[32]

Figure 9: Photo of informal settlement fire, South Africa, 2018

Source: Justin Sullivan, 2018.

[31] E.K. Addai, S.K. Tulashie, J.S. Annan, and I. Yeboah (2016), "Trend of Fire Outbreaks in Ghana and Ways to Prevent These Incidents," *Safety and Health at Work* 7(4): 284–92. doi:10.1016/j.shaw.2016.02.004.
[32] See for example, R.S. Walls, R. Eksteen, C. Kahanji, and A. Cicione (2018), "Appraisal of Fire Safety Interventions and Strategies for Informal Settlements in South Africa," *Disaster Prevention and Management*, DOI 10.1108/DPM-10-2018-0350; and C. Kahanji, R.S. Walls, and A. Cicione (2019), "Fire Spread Analysis for the 2017 Imizamo Yethu Informal Settlement Conflagration in South Africa, *Int J Disaster Risk Reduct* (April), doi:10.1016/j.ijdrr.2019.101146.

The situation has been identified as a concern on the African continent. Citing United Nations (UN) data, it has been noted that "the current population (in Africa) of 1.2 billion is expected to grow to around 2.5 billion by 2050, while at the same time the proportion of people living in urban areas is expected to increase from 40 percent to 56 percent . This means that the urban population will grow by around 920 million people in the next 30 to 35 years. It is inevitable that there will be insufficient housing, leading to larger numbers of people living in informal settlements where fire safety is very poor."[33]

To provide a sense of the extent of the problem, Table 2 presents representative fires of significance that have occurred in Africa in just the past few years. See Appendix F for an in-depth case study on South Africa.

Table 2: Recent large impact fires in Africa

Year	Location	Incident
2019	Johannesburg, South Africa	Fire in 23-story Bank of Lisbon building in the CBD claimed 3 firefighters' lives. It was reported that the building was not in compliance with regulations.[34]
2018	Khayalitsha, Cape Town, South Africa	Two separate fires over one weekend destroyed at least 1,000 homes and left at least 4,000 people homeless.[35]
2018	Alexandra, Johannesburg, South Africa	At least 500 homes were destroyed and at least 2,000 people were left homeless.[33]
2018	Plastic View and Cemetery View, Pretoria, South Africa	Three fires in a two-month span destroyed at least 422 homes and left at least 1,160 people homeless. The first fire, at Plastic View, destroyed 50 homes and left 500 people displaced. Two days later, a second fire broke out at Plastic View 2, otherwise known as Cemetery View. Some 340 were left homeless and at least 223 of the 1,000 homes were razed to the ground. In the third fire, 139 homes were razed by another fire at Cemetery View, leaving 320 people homeless. [33]
2018	Nairobi, Kenya	A market fire injured 70 injured and killed 15. Multiple fires have occurred in the area.[31]
2017	Knysna, South Africa	This wildland-urban interface fire saw the largest deployment of firefighters in the country's history. Almost 1,000 homes were destroyed.[31]
2017	Cape Town, South Africa	An informal settlement fire in densely populated settlement named Imizamo Yethu, left 10,000 people homeless.[30]
2015	Tema, Ghana	The largest storage facility for medical supplies in Ghana was destroyed in this fire. The repository also served other West African nations, thereby affecting medical supplies for the entire region.[35]

Source: Authors.

[33] R.S. Walls, A. Cicione, B. Messerschmidt, and K. Almand (2019), "Africa: The Next Frontier for Fire Safety Engineering?" *Interflam 2019, Proc.*, Vol. 1, London, p. 819–29.

[34] https://www.thesouthafrican.com/news/johannesburg-building-fire-three-firefighters-confirmed-dead/ (access April 2020).

[35] Data obtained from Iris-fire compilations of media-reported fire events, https://www.iris-fire.com/downloads/media-reports-of-is-fires/ (accessed April 2020).

Figure 10: Aerial view of extent of damage following fire in an informal settlement, South Africa, 2018

Source: Justin Sullivan, 2018.

The impact of some of the fires in Table 2 are clear, such as the informal settlement fire in Imizamo Yethu, Cape Town, that left 10,000 people homeless and had direct costs of some US$8 million.[36] Likewise, a high-rise building fire in a central business district, in which three firefighters perished, pointed to fundamental concerns with the building fire safety regulatory system. These concerns also exist when manufacturing expands into inadequately designed buildings, as has been observed in the ready-made garment districts in Bangladesh.[37] Overall, the combination of inadequately constructed and highly combustible buildings, large fuel loads, and extensive sources of potential ignition leaves these areas susceptible to more frequent, larger, and more impactful fires as compared with urban areas that have formal planning and building regulation, appropriate electrical infrastructure, good regulatory enforcement, and adequate fire service resources.

However, some fire incidents that do not seem large on the surface can have devastating impacts as well. For example, the destruction of the medical storage facility in Ghana in 2015 had far-reaching impacts. The facility supplied equipment and medicine for treating HIV/AIDS, Ebola, tuberculosis, and other diseases for 216 districts in Ghana, and the impact of the fire included an estimated loss of medical supplies valued at US$68 million and the loss of three months' worth of drug reserves.[38]

Research into the medical supply storage fire in Ghana determined that, while a building fire safety regulatory system was in place, the requirements were not met.[34] The system included processes for the approval of planning schemes and architectural and engineering designs. Regulatory requirements included various fire safety measures, hydrants, and use of closed-circuit television cameras to be inspected and certified by the appropriate agencies before granting an occupancy permit. The research indicated that several of these safety requirements had not been met. The fire hydrant at the facility was out of order at the time of the incident, the fire safety certificate for the premises had long expired, and the fire extinguishers were inappropriate. Furthermore, questions were raised as to why the facility was not equipped with the

[36] C. Kahanji, R.S. Walls, and A. Cicione (2019), "Fire Spread Analysis for the 2017 Imizamo Yethu Informal Settlement Conflagration in South Africa," *Int J Disaster Risk Reduct* (April), doi:10.1016/j.ijdrr.2019.101146.
[37] Md. Mizanuzzaman (2016), "Loss and Damage Assessment in the Context of Fire Hazards: A Study on Selected Garment Factories in Bangladesh," *International Journal of Finance and Banking Research* 2 (2): 24–39, doi 10.11648/j.ijfbr.20160202.11.
[38] E. Owusu-Sekyere, R.Y. Adjuik, and E. Wedam (2017), "The Central Medical Store Fire Disaster: A Test for Institutional Compliance in Disaster Prevention in Ghana," SAGE Open 7 (2), doi:10.1177/2158244017699528.

latest technology, such as smoke detectors and automatic sprinklers, which could have mitigated the severity of the damage. As urban areas grow, so do the need for and presence of distribution centers for critical materials, such as this medical storage facility. As critical facilities, they must be adequately protected for the full range of expected hazard events, including fire.

In short, rapidly developing urban areas without a robust planning, building, and fire regulatory system may harbor inadequately constructed and highly combustible buildings with large fuel loads, extensive sources of potential ignition from unprotected electrical systems, and open-flame cooking or heating apparatuses. These areas are often densely populated and characterized by poverty and other vulnerabilities. As noted, such areas are susceptible to more frequent, larger, and more impactful fires as compared with urban areas that have formal planning and building regulation, appropriate electrical infrastructure, good regulatory enforcement, and adequate fire service resources.

A robust building fire safety regulatory system is required to identify and provide regulatory measures necessary for protection against a wide range of fire risks and hazards. Table 3 below lists some of the potential fire risks and hazards as well as some potential mitigation measures.

Table 3: Fire hazards and risks and potential mitigation measures

Potential Fire Hazards and Risks	→	Potential Mitigation Measures
Use of inadequately controlled construction materials that can be prone to failure.		Regulate for site inspection of materials (i.e. concrete, reinforcing bars, steel, etc.).
Use of combustible building materials; inadequate spacing between combustible construction.		Regulate (limit) use of combustible building materials; require fire protection systems/features; increase distance between buildings; require adequate fire service access.
Nature of building use presents risk or hazard (e.g., risk due to occupant number or characteristics or hazard due to operations).		Classify buildings by risk to occupants and/or hazards associated with the building, in terms of life safety, property protection, mission.
Presence of inadequately protected electricity distribution infrastructure.		Regulate for safe electricity distribution at city and building levels.
Control of potential sources of ignition (e.g., electrical connections to and within buildings, and open-flame cooking and heating devices).		Regulate for safe electricity distribution at city and building levels; regulate/ provide alternatives for open-flame cooking and heating; promote no-smoking policies.
Control of sources of fuel: from fuels for heating and cooking, to construction materials, to normal and hazardous/combustible/flammable contents.		Regulate to minimize combustible construction; regulate/provide alternatives for open-flame cooking and heating; separate hazardous facilities from residential areas.
Inadequate fire service infrastructure and site access.		Regulate for wider roads/access for fire apparatus; add firefighting water infrastructure and storage.

Source: Authors.

2.2 Establishing Minimum Standards for Life Safety in Case of Fire

Building occupant safety is largely a function of building construction materials (combustible or not), separation distance between buildings (to limit fire spread), interior and exterior surface covering materials (e.g., interior and exterior wall linings), arrangement and protection of means of escape (e.g., corridors, stairs, doors within buildings, avenues and streets around buildings), fire protection systems installed (e.g., exit signs and lighting, smoke alarms, and fire suppression equipment), and systems and features to support firefighter rescue and suppression activities.

In this regard, building fire safety regulations are essential for defining and controlling hazards and risks and for providing for adequate protection against fire impacts with regard to occupant safety in case of fire. This encompasses control of potential sources of ignition associated with building occupancy, including electrical power connections to buildings and cabling, equipment, and components within buildings. Controls around heating and cooking appliances, in particular those using open flames fueled by flammable gases and other fuels, are also included.

Figure 11: (a) Numerous illegal connections (all except top two lines) onto electrical infrastructure; (b) steep rocky terrain making access difficult; (c) dwellings located close to each other; and (d) narrow access ways between houses

Source: Kahanji C, Walls RS, Cicione A. (2019) Fire spread analysis for the 2017 Imizamo Yethu informal settlement conflagration in South Africa. Int J Disaster Risk Reduct. April 2019. doi:10.1016/j.ijdrr.2019.101146

Building fire safety regulations also define the expected fire performance of the structure; escape (egress) system requirements, in terms of fire performance of exit enclosures (e.g., rooms, corridors, stairwells); location and performance of exit signage and lighting; fire detection and alarm requirements for notifying occupants; and smoke control, fire extinguishing, and suppression requirements. These and related systems and features are essential in helping to control fire ignition and limit the development and spread of fire, should it occur, for a period of time adequate to allow occupants to escape safely.

2.3 Establishing Minimum Standards for Protection of Property in Case of Fire

Requirements for preventing structural collapse due to fire, means to control the spread of fire from one compartment to another, and controls to keep fires from exterior sources from spreading into buildings are critical for safeguarding property in the event of a fire initiated either inside or outside of a building. This is important to protect the physical asset (the building), its operations (mission), and its contents.

Protecting these features is incredibly important to protecting building stock and facilitating continued economic productivity following a fire. Inadequate fire resistance requirements for structural systems and for interior partitions can lead to significant fire spread within a building and can lead, in some cases, to collapse. This has been seen in high-income countries, such as with the Faculty of Architecture Building, Delft University of Technology, in the Netherlands in 2008,[39] and the Windsor Building fire in Madrid in 2005.[40]

Figure 12: Post-fire collapse of Faculty of Architecture Building, Delft University of Technology, 2008

Source: Hans Schouten, Creative Commons, 2008.

[39] B.J. Meacham, M. Engelhardt, and V. Kodur (2009), "Collection of Data on Fire and Collapse, Faculty of Architecture Building, Delft University of Technology," 2009 CMMI Engineering Research and Innovation Conference, National Science Foundation, June.

[40] A. Montalva, V. Pons i Frigola, O. Herrera, R. Gilsanz, and V. Pons i Grau (2009), "A Catastrophic Collapse: Windsor Building Fire (Madrid, 2005)," *Forensic Engineering: From Failure to Understanding* (January): 372–82.

However, the problem can be far greater in cities and countries that do not have robust building regulatory systems that lack adequate requirements for material strength and fire performance properties, including fire resistance. Hundreds of deaths, thousands of injuries, and significant direct and indirect property losses have been caused by warehouse and factory fires and structural collapses in Bangladesh.[41] Control of fire spread between buildings is a significant challenge in areas with considerable amounts of combustible construction, such as areas of informal settlements, urban markets, and the like, which are often present in LMICs. Much has been done recently to better understand fire spread challenges in informal construction,[42] but a formal building fire safety regulatory system is still required to provide the range of regulatory provisions, test requirements, certifications, inspections, and similar efforts necessary to facilitate better-performing buildings.

Case Study 3: Myanmar

Township Fire, Yangon, Myanmar

For 2019, the Myanmar Fire Services Department reported about 2,500 fires, which killed more than 79 people and left 6,300 homeless. The estimated property damage reached US$2 million. Although the accuracy of the official numbers is contested, fires have had a significant impact across the country's urban areas. Among the frequent fire disasters in Yangon, some stand out for their destructive aftermath; for example, on December 29, 2011, a fire followed by several explosions in a compound of warehouses in the Mingalar Taungnyunt township of Yangon killed at least 17 people and injured more than 90. The fire, which started in the warehouse, quickly spread and ravaged nearby wooden houses. The warehouses were said to contain chemicals and construction materials.

Sources: Myanmar Times (2020), and Reuters (2011), "Gunpowder Warehouse Blast Kills 17 in Myanmar," https://br.reuters.com/article/oukwd-uk-myanmar-blast-idAFTRE7BR1FI20111229.

Case Study 4: Jamaica

Market fires across Jamaica

Since 2015, it is estimated that $385 million worth in damage has been left in the wake of 18 market fires. During this five-year period, the Jamaica Fire Brigade reported 11 such fires in the urban areas of Kingston and St Andrew, with estimated losses of US$212.7 million. These fires were caused by a combination of factors: stands built with highly flammable materials; faulty, unregulated electric installations; lack of planning and adherence to design standards; and complex land use, with several vendors living and sleeping on market premises, raising the risk of energy and service overuse. The economic impact of these fires affects thousands of livelihoods, a loss further accentuated by the slow reconstruction processes.

Sources: Gleaner (2019), "$400m Market Fires — Vendors Devastated as Montego Bay Old Fort Razed," http://jamaica-gleaner.com/article/lead-stories/20191210/400m-market-*fires-vendors-devastated-montego-bay-old-fort-razed.*

[41] For example, https://www.cnn.com/2012/11/25/world/asia/bangladesh-factory-fire/index.html, https://www.reuters.com/article/us-bangladesh-fire/bangladesh-garment-factory-fire-kills-12-idUSKCN11G05R, https://www.india.com/news/world/bangladesh-chemical-warehouse-fire-death-toll-rises-to-81-over-50-injured-3584982/ (all accessed January 2020).

[42] Y. Wang, C. Bertrand, M. Beshir, C. Kahanji, R. Walls, and D. Rush (2020), "Developing an Experimental Database of Burning Characteristics of Combustible Informal Dwelling Materials Based on South African Informal Settlement Investigation," *Fire Safety Journal* 111, http://www.sciencedirect.com/science/article/pii/S0379711219303194.

A robust building fire safety regulatory system includes requirements for structural performance in the case of fire, for fire resistant interior compartmentation (walls, floors, ceilings), and for resisting the spread of fire via openings in exterior walls (from inside to outside and vice versa). They also include requirements for materials inspection (e.g., concrete mixes, appropriate reinforcing steel bars (rebar), proper connections) and inspection of buildings in use. These are fundamental to assuring safely designed, constructed, and operated buildings.

2.4 Establishing Minimum Standards for Limiting the Potential for Urban Conflagration

Conflagration potential in urban environments can be significant if characterized by large amounts of combustible construction, densely packed buildings, and few impediments to fire spread. This has been widely recognized by cities and countries worldwide and has been a significant contributor to the development and implementation of formal building regulatory systems in many of them.

In the United States, for example, conflagrations in Chicago (1871), Boston (1872), and Baltimore (1904) profoundly affected building fire regulations, the development of consensus standards for fire protection systems, and product certification via the insurance industry.[43] In 1870, the year before the Chicago conflagration, Lloyd's of London stopped writing policies in Chicago because of the haphazard manner of construction there. About the same time, the National Board of Fire Underwriters (NBFU), established in 1866, realized that rate adjustments were insufficient for addressing the fire problem; it began to emphasize safe building construction, fire hazard controls, and improved water supplies and fire departments. Over time, the NBFU saw real benefits from their building and fire-safety recommendations, and, in 1905, it published what is considered the first model building fire code for the United States.

At about the same time, product testing and certification and standardization of fire safety features began. Underwriters Laboratories was established in 1894, focusing initially on testing and certification for products and systems using the new technology, electricity.[44] In 1896, the National Fire Protection Association (NFPA) was formed by a group of fire organizations, both to respond to the significant fires of the era and to coordinate codes and standards for new technologies, such as fire sprinklers.[45] The 1904 Baltimore conflagration ushered in the era of standardization of fire department equipment, after the numerous fire apparatuses from neighboring cities and towns, as well as Philadelphia and New York, could be put to little or no use in fighting the fire because their hoses would not fit Baltimore's hydrants.[46] The 1906 San Francisco fire, and a motivated insurance industry, led to the formation of the International Conference of Building Officials (ICBO), which published the first model building code in the USA in 1923.[47]

Today, as urban centers in LMICs expand, the risk of urban conflagration remains. Even if some level of building fire safety regulatory system is in place, as in South Africa, Brazil, and India, problems emerge when informal construction is located in and around formal construction. Informal buildings are often combustible and facilitate fire spread. An example is the fire that developed in the Estrada de Alpina favela of São Paulo, which destroyed hundreds of informal homes.[48] Similar fires occur rather frequently in India, Bangladesh, and across the African continent as well.[49]

[43] A.E. Cote and C.C. Grant, (1997), "Building and Fire Codes and Standards," *Fire Protection Handbook*, 18th ed. (Quincy, MA: NFPA), 1.42–1.54.
[44] S.E. Wermiel (2000), *The Fireproof Building: Technology and Public Safety in the Nineteenth-Century American City* (Baltimore, MD: Johns Hopkins University Press).
[45] https://www.nfpa.org/About-NFPA/NFPA-overview/History-of-NFPA.
[46] D. Hemenway (1975), *Industrywide Voluntary Product Standards* (Cambridge, MA: Ballinger Publishing Company).
[47] C.H. Geschwind (2001), *California Earthquakes: Science, Risk and the Politics of Hazard Mitigation* (Baltimore, MD: Johns Hopkins University Press).
[48] "Favela in flames: Aerial footage shows fire ripping through Brazilian slum," ABC News, Australia, 2016, https://www.abc.net.au/news/2016-09-14/fire-sweeps-through-sao-paulo-favela/7843336 (accessed February 2020).
[49] A listing of informal settlement fires can be found at https://www.iris-fire.com/downloads/media-reports-of-is-fires/.

Figure 13: Photo of informal settlement fire, South Africa, 2018

Source: Justin Sullivan, 2018.

Case Study 5: South Africa

Fires in informal settlements, Cape Town, South Africa

Up to one-third of the population of South Africa is estimated to live in informal settlements. In Cape Town alone the number of informal dwellings grew from around 28,000 in 1993 to 104,000 in 2006. Cape Town has become South Africa's most fire-prone city: out of the four largest South African metropolitan centers, this urban area has the highest overall fire-related death rate. Among the frequent fire disasters in Cape Town, some stand out for their destructive aftermath. On March 11, 2017, a fire swept through Cape Town's Imizamo Yethu township. Four lives were lost, 2,194 structures were destroyed, and 9,700 people were displaced. It was one of the worst fires in Cape Town's history.

*Sources: The Conversation (*2019), "IRIS Fire: About the IRIS Fire Project," https://www.iris-fire.com/about-1/; "How Cities Can Approach Redesigning Informal Settlements after Disasters, https://theconversation.com/how-cities-can-approach-redesigning-informal-settlements-after-disasters-116318.

Over time, where countries have implemented robust building fire safety regulatory systems and associated support infrastructure, the urban conflagration hazard has been significantly reduced. If such systems are not in place as urban areas expand, the threat of conflagration will remain very real. This threat will only be exacerbated by the presence of informal buildings, inadequate electrical installations, widespread ad hoc use of open-flame fires for cooking and heating, and population and building densities that restrict access by emergency personnel.

2.5 Enhancing Multi-Hazard Mitigation Measures

While fire is a significant hazard on its own, it is also one that can occur after a natural hazard event, such as earthquake, cyclone, or flood, when infrastructure may be damaged and already insufficient resources are spread even thinner. Fire should always be considered as part of multi-hazard mitigation planning for countries prone to significant natural hazards, in particular those with large amounts of combustible construction (formal or informal), inadequate infrastructure (including electricity distribution, gas distribution, water distribution, and access roads), and under-resourced fire and emergency services.

Post-earthquake fire has been a known concern for hundreds of years; examples of such events include fires in 1906 San Francisco, 1923 Tokyo, and 1995 Kobe. As discussed in Section 1, modern building regulatory systems, including fire protection provisions, were created as a result of such events. The risk of post-earthquake fire remains high in densely packed urban environments with the characteristics noted above.

Fire following flooding has also been a long-standing concern. When an area floods, electricity and other infrastructure is often lost and roads become impassible; should a fire occur, it can be impossible for the fire service and other emergency responders to undertake their mission.

A recent example was the fire following flooding initiated by Superstorm Sandy in 2012 in the U.S. state of New York. During this storm, a fire occurred in the Breezy Point neighborhood of the borough of Queens. However, due the high flood waters, some volunteer firefighters could not respond, and the fire department was unable to get fire apparatus near the initial fire location. Given the storm's high winds, the fire soon spread, ultimately destroying more than 100 homes. The disaster mitigation planning that had been in place had not considered fire during or following flooding — just flood control.[50]

Figure 14: Aerial view of flood and fire damage caused by Hurricane Sandy, Breezy Point Neighborhood, Queens, NY, 2012

Source: Andrea Booher, FEMA, 2012.

[50] As described in FEMA P-942, Mitigation Assessment Team Report: Hurricane Sandy in New Jersey and New York (2013), the scope of the New York State Department of Environmental Conservation (NYSDEC) Coastal Management Section is to reduce coastal erosion and storm damage to protect lives, natural resources, and properties through structural and nonstructural means; the Floodplain Management Section is responsible for reducing flood risk to life and property through management of activities, such as development in flood hazard areas, and for reviewing and developing revised flood maps. Fire during flooding was not in the scope of duties for either section.

2.6 Helping to Reduce Impacts on the Climate from Fire Events and Increasing Climate Change Resilience

Fire can result in impacts to the environment[51] and contribute to climate change.[52] The release of carbon during fires can be significant, especially in large building fires, multi-building fires (conflagrations), fuel storage fires, and wildland fires. With respect to buildings, measures to prevent fire from occurring and to mitigate the impact of fire should it occur are attributes of robust building regulatory systems. Decreasing fire occurrences and magnitudes reduces impacts on the environment and climate change.

The range of construction materials, systems in and on buildings, contents of buildings, and sources of potential ignition pose just as many — if not more — hazards and risks today as they did in the past. Some of the increased hazard and risk is associated with "green" or sustainable features and technologies in buildings.[53] It can be difficult to manage potentially competing objectives, such as sustainability and fire safety, even in well-developed building fire safety regulatory systems.[54] This is evident in the tragic Grenfell Tower fire in London; that fire, which killed more than 70 people, has been attributed in part to gaps in the building fire safety regulatory framework that allowed highly combustible material to be wrapped around the building, combined with inadequate interior fire safety features and occupant fire safety management strategies that had been developed for different building layouts.[55]

Figure 15: Aerial view of wildland fire in South Africa, 2017

Source: Antti Lipponen, 2017.

[51] M. McNamee, G. Marlair, B. Truchot, and B. Meacham (2020), *Research Roadmap: Environmental Impact of Fires in the Built Environment* (Quincy, MA: Fire Protection Research Foundation).
[52] D.M.J.S. Bowman, J.K. Balch, P. Artaxo, W.J. Bond, J.M. Carlson, M.A. Cochrane, C.M. D'Antonio, R.S. DeFries, J.C. Doyle, S.P. Harrison, F.H. Johnston, J.E. Keeley, M.A. Krawchuk, C.A. Kull, J.B. Marston, M.A. Moritz, I.C. Prentice, C.I. Roos, A.C. Scott, T.W. Swetnam, G.R. van der Werf, and S.J. Pyne (2009), "Fire in the Earth System," *Science* 324 (5926): 481–84, DOI: 10.1126/science.1163886.
[53] B. Meacham, B. Poole, J. Echeverria, R. Cheng (2013), "Fire Safety Challenges of Green Buildings," *Springer Briefs in Fire*, J. Milke, series ed., Springer, DOI:10.1007/978-1-4614-8142-3.
[54] B.J. Meacham, "Sustainability and Resiliency Issues and Objectives in Performance Building Regulations," *Building Governance and Climate Change: Regulation and Related Polices, Building Research and Information* 44 (5–6), Special Edition, DOI:10.1080/09613218.2016.1142330.
[55] Ministry of Housing Communities & Local Government (2018), *Building a Safer Future Independent Review of Building Regulations and Fire Safety: Final Report*; B.J. Meacham and M. Stromgren (2019), "A Review of the English and Swedish Building Regulatory Systems for Fire Safety using a Socio-Technical System (STS) Based Methodology," HOLIFAS Project WP 3 Report, Briab Brand & Riskingenjörerna AB (Sweden) and Meacham Associates (USA) Research Report 2019:01, http://dx.doi.org/10.13140/RG.2.2.34702.72001.

In addition to fire being a source of environmental impact and contributor to climate change, some of the climate change impacts, such as more extensive areas and periods of drought and increased temperature, can contribute to the frequency and magnitude of wildland fires. [56] As urban areas grow, many encroach on forests and grasslands, increasing the urban-wildland interface (WUI) fire problem in both LMIC[57] and high-income countries.[58] At the end of 2019 and into 2020, for example, bushfires raged across vast portions of Australia. The magnitude of the impacts included burning 18 million hectares; several human fatalities; destruction of over 5,900 buildings, including over 2,800 homes; and many millions of animal fatalities.[59] The economic impacts are still being assessed, but estimates being reported are upwards of $A4.4 billion in overall economic impact.[60]

Globally, loss due to wildland fire is presently greater than at any time in the past. The U.S. National Institute of Standards and Technology (NIST) estimated in 2017 that the total economic burden of wildland fire in the United States alone was between US$71 billion and US$347 billion (2016).[61] This problem has, and will continue, to impact LMICs as well. Across the African continent, wildland fire is a concern, and with urban areas encroaching on the wildland, wildland-urban interface fires are an ever-greater issue.

2.7 Helping to Reduce Economic Impacts of Fire

With respect to formal construction, the cost to rebuild a significantly fire damaged structure will almost always be greater than the cost of protecting the asset from the outset, especially if the costs of material and labor increase with time. Globally, financial losses to insured commercial properties and business operations cost upwards of US$20 billion in 2018.[62] This includes not only the impact on the building and operation at the fire source but also the impacts throughout the supply chain and on consumer confidence. If international companies do not consider building fire safety regulations to be sufficiently robust, they may choose not to build or rebuild in a particular country if the potential economic losses are perceived to be too great, especially if the insurance market is lacking as well.

In Bangladesh, costs to government, local businesses, and their international trading partners, including the resources expended by the Accord on Fire and Building Safety in Bangladesh (Accord) and the Alliance for Bangladesh Worker Safety (Alliance) have been significant. The cost to local companies for only six of the fires is estimated at almost US$365 million,[63] not including associated losses (e.g., human losses, direct and indirect losses on the supply chain, and infrastructure impacts). Across the ready-made garment sector as a whole, initial cost estimates for remediation were some US$929 million, of which US$372 million was associated with electrical and fire issues and the balance with structural safety.[64] While pre-event thinking might have considered the fire safety risks “tolerable” in comparison with the cost of making buildings safe, the global response to inadequate safety provisions for workers was clear following the fires, resulting in formation of the Accord and the Alliance. A robust building fire safety regulatory system can be beneficial in helping to increase the fire resiliency of buildings and mitigate against such major direct and indirect losses.

[56] J.T. Abatzoglou and A.P. Williams (2016), “Climate Change Has Added to Western US Forest Fire,” *Proceedings of the National Academy of Sciences* 113 (42): 11770–11775, DOI:10.1073/pnas.1607171113.
[57] L. Vilà-Vilardell, W.S. Keeton, D. Thom, C. Gyeltshen, K. Tshering, and G. Gratzer (2020), “Climate Change Effects on Wildfire Hazards in the Wildland-Urban-Interface – Blue Pine Forests of Bhutan,” *Forest Ecology and Management* 461 (117927), ISSN 0378-1127, https://doi.org/10.1016/j.foreco.2020.117927.
[58] For example, see https://www.nist.gov/industry-impacts/reducing-impact-wildland-urban-interface-fires (accessed April 2020).
[59] https://www.unenvironment.org/news-and-stories/story/ten-impacts-australian-bushfires (accessed April 2020).
[60] https://www.theguardian.com/australia-news/2020/jan/08/economic-impact-of-australias-bushfires-set-to-exceed-44bn-cost-of-black-saturday (accessed April 2020).
[61] D. Thomas, D. Butry, S. Gilbert, D. Webb, and J. Fung (2017), *The Costs and Losses of Wildfires – A Literature Review*, NIST Special Publication 1215, U.S. National Institute of Standards and Technology, Gaithersburg, MD, https://doi.org/10.6028/NIST.SP.1215 (accessed January 2020).
[62] Allianz Global Corporate & Speciality (2018), *Global Claims Review: The Top Causes of Corporate Insurance Losses*, https://www.agcs.allianz.com/content/dam/onemarketing/agcs/agcs/reports/AGCS-Global-Claims-Review-2018.pdf (accessed January 2020).
[63] Md. Mizanuzzaman (2016), “Loss and Damage Assessment in the Context of Fire Hazards: A Study on Selected Garment Factories in Bangladesh,” *International Journal of Finance and Banking Research* 2 (2): 24–39, doi 10.11648/j.ijfbr.20160202.11.
[64] *Remediation Financing in Bangladesh’s Ready-Made Garment Sector: An Overview* (2016), prepared by Emerging Markets Consulting for the International Labour Organization and the International Finance Corporation; Copyright © International Labour Organization/International Finance Corporation 2016.

Arguably the picture is not so clear with informal construction, in particular housing. If a dwelling is built from previously used or recycled materials, then the cost to rebuild using more such materials can be cheaper for the inhabitant(s) than building a fire-safe building to start with (not counting cost of lost personal belongings). They also would not have the capital available upfront to build a fire-safe home. However, some combination of micro-financing, government-supported formal housing and/or provision of fire-resilient building materials, fire-safe planning within informal settlements on rebuild could help. A building fire safety regulatory system that incorporates such concepts would help facilitate such options.

Case Study 6: Morocco

Industrial site and market fires across Morocco

In Morocco, industrial sites are particularly vulnerable to fire. On April 26, 2008, a rapidly spreading fire in a mattress factory in Casablanca killed at least 55 people and seriously injured 12. Investigators found that the factory was not complying with minimum fire safety standards. On November 26, 2002, in the port of Mohammedia, fire consumed one of Morocco's largest oil refineries, resulting in an estimated loss of US$140 million. Morocco's markets and souks are also highly vulnerable to the propagation of fire. For example, on March 24, 2004, a fire ravaged the Souk Ould Mina in Casablanca, and on September 5, 2019, and again on March 1, 2020, fires ravaged the souk "Al-Massira" in Hay Moulay Rachid in Casablanca, destroying the livelihoods of many.

Source: France24 (2008), "Scores Killed by Factory Fire in Morocco," https://www.france24.com/en/20080427-scores-killed-factory-fire-morocco-morocco /; GulfNews (2002), "Fire-Hit Refinery to Fully Recover Within 13 Months."

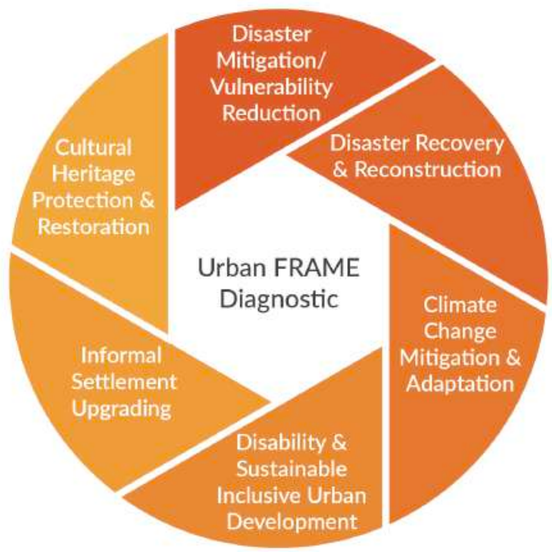
Figure 16: Fire at Tampaco Foils Factory, Bangladesh, 2016

Source: Jubair Bin Iqbal, 2016.

3.0 SECTORS OF ENGAGEMENT

As explained in Section 1, the Urban FRAME diagnostic facilitates assessment of the existing fire safety regulatory system situation and identification of areas for improvement. The Urban FRAME diagnostic can assist project managers, government officials, and other interested and affected parties to identify gaps in the fire safety regulatory system of a city or country. It is applicable to a wide range of project types and can be implemented at various stages of assessment and planning.

Figure 17: Applicability of the Urban Fire Regulatory Assessment and Mitigation Evaluation (Urban FRAME)



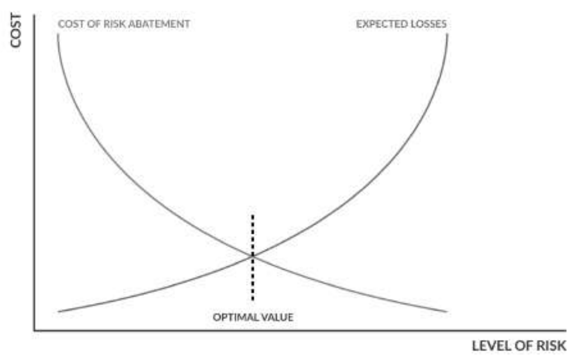
3.1 Disaster Risk Mitigation and Vulnerability Reduction Programs

The understanding is widespread that mitigating risk before an event is significantly more cost-effective than recovering from a catastrophe. However, this does not mean implementing every possible risk reduction option. Rather, the aim is to optimize risk reduction measures as compared with unmitigated (post-disaster) loss expectations.

Risk reduction strategies must balance risk reduction opportunities and associated costs, as well as potential risks and associated losses. In general, risk reduction strategies must aim for the highest level of protection and safety that can be achieved with available resources. The general concept of risk-cost optimization is shown in Figure 18. One could spend considerable funds in reducing risk to a very low level (left side) or spend little on risk abatement but have the potential for significant expected losses (right side). A cost-optimal point balances mitigation costs and expected losses.

In many respects, building regulatory frameworks are mechanisms for optimizing societal risk reduction. When an effective building regulatory system is in place, hazards are addressed by relevant legislation, regulations, and appropriate oversight; when suitable market mechanisms are in place (e.g., suitable materials, a competent workforce, financing, and insurance), the system works to mitigate risks to a socially and economically tolerable level.

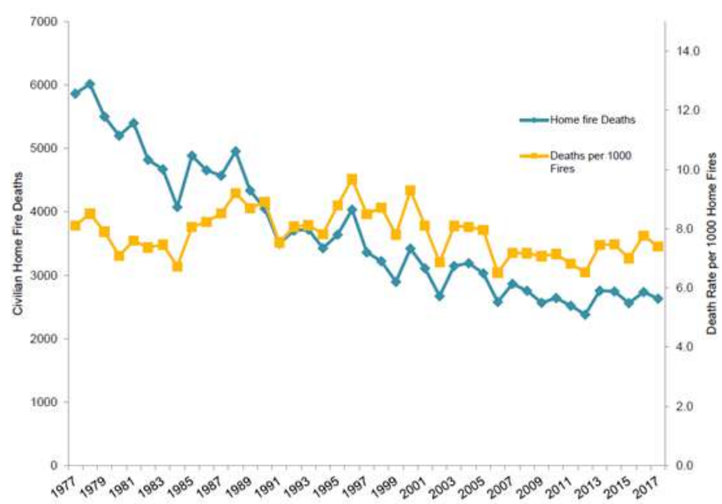
Figure 18: Generalized concept of risk-cost optimization



With respect to fire, regulation, and the market, consider fire deaths in the United States over the past 40 years. In 1977, deaths due to fire numbered about 7,400. By 2016, that figure had dropped to about 3,200.[65] Each year, the majority of deaths occur in the home. While the predominant domestic housing construction stayed the same — lightweight timber-framed buildings — factors such as the addition of home smoke alarms,[66] changes in flammability requirements for furniture[67] and bedding material, reduced smoking by the U.S. population,[68] and better building fire safety provisions in regulations[69] led significantly reduced home fire deaths. Similar trends appear in Japan, where in addition to requiring smoke alarms (starting in 2007), traditional open-flame heating systems have largely been replaced by heat pump technology, and cooking stoves now must have automatic shutoffs.[70]

By contrast, fire deaths in LMICs are increasing. This can be seen from the total number of fire incidents reported in Ghana from 2000 to 2014 (Figure 20), where the increase is attributed to "rate of population growth and industrialization, unstable electricity, urbanization, negligence, illegal electrical connection, etc."[71] Another example emerges from South Africa's data, showing an increase in fire incidents from 2003 through 2016 (Figure 21).[72]

Figure 19: U.S. fire death trends — 1977-2018



Source: NFPA, Urban FRAME Diagnostic Workshop Presentation, 2019.

65 B. Evarts (2019), "Fire Loss in the United States During 2018," NFPA, Quincy, MA.

66 G.R. Istre and S. Mallonee (2000), "Smoke Alarms and Prevention of House-Fire-Related Deaths and Injuries." *Western Journal of Medicine* 173 (2): 92–93, https://doi.org/10.1136/ewjm.173.2.92.

67 "White Paper on Uphosltered Furniture Flammability" (2013), NFPA, Quincy, MA, https://www.nfpa.org/-/media/Files/Fire-Sprinkler-Initiative/Fire-Threats-in-New-Homes-Research/Fire-Loss-and-Injuries/Upholstered-Furniture-White-Paper.ashx?la=en (accessed April 2020).

68 B.N. Leistikow, D.C. Martin, and C.E. Milano (2000), "Fire Injuries, Disasters, and Costs from Cigarettes and Cigarette Lights: A Global Overview," *Preventive Medicine* 31 (2 Pt 1): 91–99.

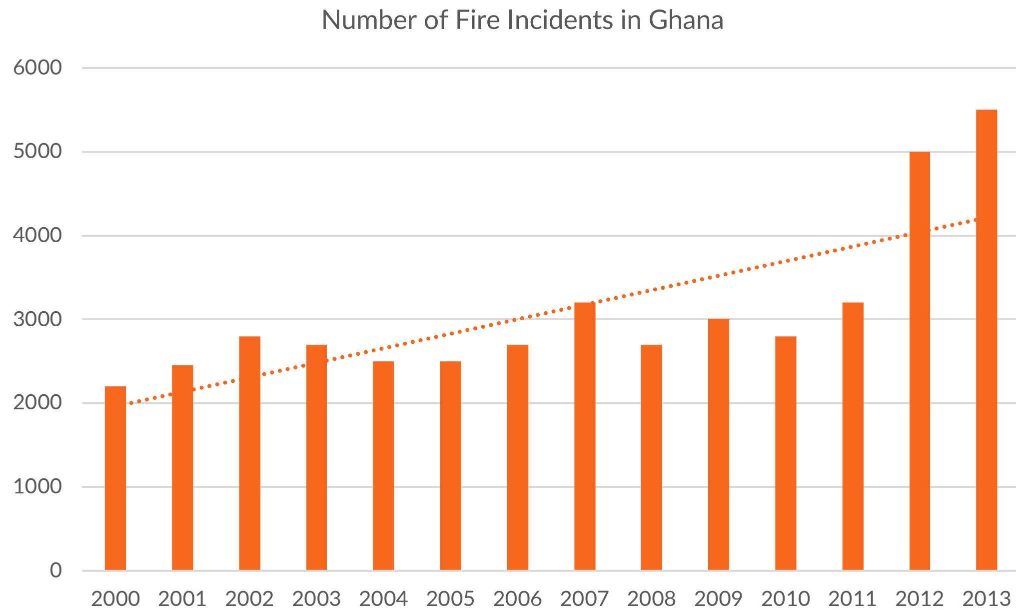
69 *Fire in the United States 2008–2017*, 20th ed. (2019), U.S. Fire Administration, FEMA, November, https://www.usfa.fema.gov/downloads/pdf/publications/fius20th.pdf (accessed April 2020).

70 A. Sekizawa (2017), "Challenges in Fire Safety in a Society Facing a Rapidly Aging Population," presentation at 5th Seminar on Fire Safety in Buildings by Fire Safety Group of São Paulo University, Brazil, October.

71 E.K. Addai, S.K. Tulashie, J.S. Annan, and I. Yeboah (2016), "Trend of Fire Outbreaks in Ghana and Ways to Prevent These Incidents," *Safety and Health at Work* 7 (4): 284–92, doi:10.1016/j.shaw.2016.02.004.

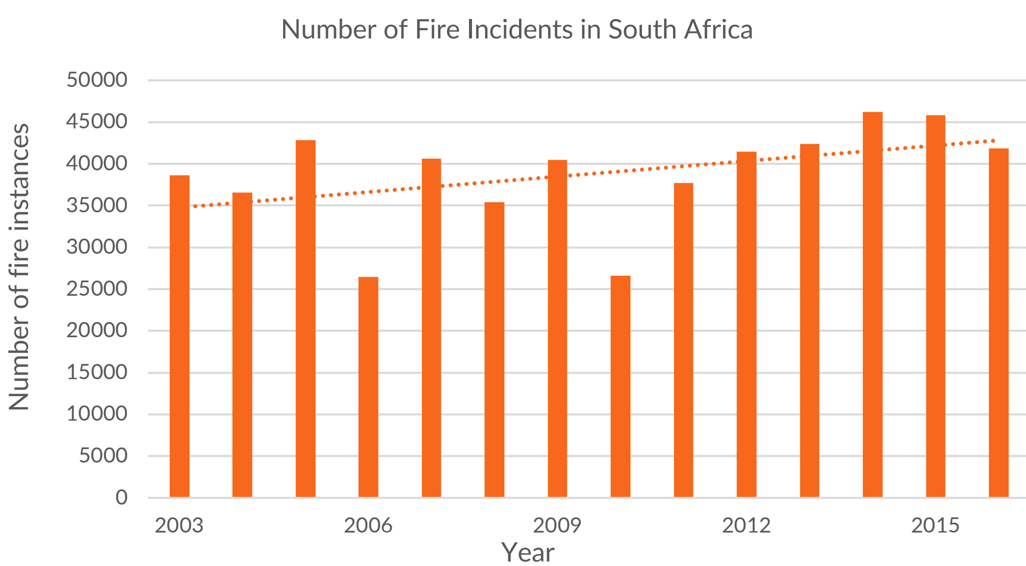
72 Richard S. Walls assessment, based on using fire loss statistics reported by the South African Fire Protection Association, 2016.

Figure 20: Trend in number of fire incidents in Ghana



Source: Figure based on estimates in E.K. Addai, S.K. Tulashie, J.S. Annan, and I. Yeboah (2016), "Trend of Fire Outbreaks in Ghana and Ways to Prevent These Incidents," Safety and Health at Work 7 (4): 284–92, doi:10.1016/j.shaw.2016.02.004.

Figure 21: Trend in number of fire incidents in South Africa



Source: Richard S. Walls, using fire loss statistics reported by the South African Fire Protection Association, 2016.

If a country has a significant building and/or infrastructure disaster risk reduction, vulnerability assessment, or resiliency enhancement program underway, such as increasing seismic resilience of buildings and critical infrastructure, that program creates an opportunity to address building and fire regulatory issues as identified through a BRCA and/or an Urban FRAME assessment.

Because the fire safety regulatory system is a subset of the building regulatory system, it can be cost effective to review, assess, and enhance regulatory capacity across the hazard areas. If legal teams are already engaged in overall legal and administrative review and enhancement, adding a fire-issue assessment may not require much additional effort. Likewise, if review and update to building regulatory provisions are part of the program, including fire safety provisions in the review could be readily facilitated. The same is true when assessing the building control component, by simply including fire prevention and control functions as well. While new and different tasks will arise, requiring additional investment, the expected amount would likely be much less than for starting an Urban FRAME as an entirely new project.

How to build an Urban FRAME diagnostic into an existing buildings and/or infrastructure resilience enhancement projects is illustrated in Figure 22, which shows a hypothetical resilience enhancement project being designed (at right) and the possible opportunities for addressing BRCA and Urban FRAME outcomes (at left) within the legal and regulatory framework capacity and/or supporting institution capacity.

Case Study 7: India

Fires across India

Fires are common in India, where fire safety regulations in factories and residential buildings are often poorly enforced. In February 2020, fires in two different denim factories in Ahmedabad killed 10 people. On December 8, 2019, a fire in a factory in the Anaj Mandi area of New Delhi killed at least 43 people and injured 56. More than 100 people were sleeping inside the factory when the fire ignited. On May 24, 2019, a fire in Surat commercial complex in the state of Gujarat killed 22 students and injured many others. Some other devastating events in the country's recent past include: the April 2016 fire in Kollam temple in the state of Kerala, which killed at least 108 people and injured 400, and the July 2004 fire that tore through a Tamil Nadu school and killed 94 children.

Sources: APNews (2020), "Burned India Denim Factory Had Single Door Reached by Ladder," *https://apnews.com/article/dd8bdf94c93795a9978435d20a40f695 /*; *India Today* (2019), "43 Killed in Massive Fire in Delhi's Anaj Mandi, Rescue Efforts On as Chaos Grips Area," https://www.indiatoday.in/india/story/delhi-anaj-mandi-fire-rani-jhansi-road-fire-accident-1626301-2019-12-08 /; *India Today* (2019), "Surat Fire: 22 Killed in Coaching Centre Blaze, Horrific Visuals Show Kids Falling Off Burning Building," https://www.indiatoday.in/india/story/gujarat-surat-coaching-centre-fire-casualties-injured-fire-department-live-updates-1533860-2019-05-24 /; *AlJazeera News* (2016), "Five Held as Death Toll from India Temple Fire Rises," https://www.aljazeera.com/news/2016/04/11/five-held-as-death-toll-from-india-temple-fire-rises//; *BBC News* (2014), "Kumbakonam: Ten Jailed for India School Fire which Killed 94*,"* https://www.bbc.com/news/world-asia-india-28558562.

Figure 22: Potential entry point for BRCA and Urban FRAME on existing resiliency project

BRR Investment Activities

Investment Programs & Platforms

LEGAL AND REGULATORY FRAMEWORK

Establishes core building lifecycle quality control and assurance mechanisms in line with international good practice.

GOVERNMENT, INDUSTRY & OWNERS' CAPACITY

Develops capacity and skills of public and private sector stakeholders to promote a resilient built environment.

BUILDING INFRASTRUCTURE & RESILIENCE

Improves structural resilience of building, infrastructure and service facilities.

Building Regulatory Capacity Assessment (BRCA)

Investment Activities

Legal and Regulatory Framework:

- Legal, policy and regulatory reforms
- Building code, standards and guidelines
- Building approval process (Construction Permit Diagnostic)
- ICT infrastructure and software for digitalization of building permit process (Works and Equipment)
- Building inspection mechanism
- On-site & remote inspection (Works and Equipment)
- Standards for construction materials and methods
- Laboratory & testing equipment (Works and Equipment)
- Accreditation of building products, labs and professional organizations

Government, Industry & Owners' Capacity:

- Capacity building for planning and construction regulators (Training Needs Assessment)
- Capacity building for private building professionals
- Training of builders and construction workers
- Professional certification
- Building rating systems
- Partnership with other contributors to building safety (i.e. insurance, banking sector)

Building Infrastructure & Resilience:

- Building vulnerability assessment
- Retrofit of critical buildings (schools, hospitals, government buildings)
- Retrofit of critical infrastructure
- Subsidy program for building quality improvement and retrofitting

Urban Fire Regulatory Assessment and Mitigation Evaluation (Urban FRAME)

Investment Activities

Legal and Regulatory Framework:

- Fire safety legislation
- Fire-safe urban and land use planning
- Fire safety regulatory provisions and standards
- Fire safety review and inspection
- Fire laboratory and testing equipment

Government, Industry & Owners' Capacity:

- Capacity building for fire review and inspection
- Capacity building for fire safety design and engineering professionals
- Capacity building for tradespersons and skilled labourers
- Fire safety engineering academic program
- Appropriate fire safety technologies
- Community outreach and public education
- Fire insurance

Building Infrastructure & Resilience:

- Fire vulnerability assessment
- Fire apparatus access infrastructure (Works and Equipment)
- Fire suppression water resource and infrasructure (Works and Equipment)
- Neighberhood fire resiliency upgrading
- Fire safe electricity infrastructure (Works and Equipment)
- Building fire safety system upgrades (i.e., fire sprinklers, fire resistant materials, smoke alarms, fire extinguishers) (Works and Equipment)
- Fire safe home appliances (i.e., heating and cooking appliances, electrical systems) (Works and Equipment)

Legend

- Construction Permit Diagnostic (BRR Tool)
- Training Needs Assessment (BRR Tool)
- Works and Equipment

3.2 Disaster Recovery Projects

When a disaster occurs, a priority is naturally to help the country, region, or municipality recover and return to some semblance of normalcy. However, the opportunity also arises to assess the factors that contributed to the catastrophe and to implement measures that can reduce the probability of similar events occurring in the future. In cases where fire catastrophes are linked to concentrated population groups, whether in high-occupancy-load buildings or densely populated areas, it is likely that gaps in the building and fire regulatory system, or absence of a formal system, contributed to the loss. Examples include how and where buildings were sited (including density, separation distance, and proximity to agricultural or forested land), how the buildings were designed and constructed, what materials were used, how the buildings were operated and maintained, and the electricity, water, and fuel gas infrastructure.

As discussed in Section 2, fire following earthquake or flooding can be a major concern in earthquake- and flood-prone areas. Following an earthquake or flood, recovery activities will include seismic or flood retrofitting to formal construction, making this an ideal time to include fire remediation as well. Upgrading at such times would be more cost-effective than waiting for a fire loss and then undertaking fire remediation efforts and implementing mitigation plans. Likewise, if the disaster recovery effort involves updates to the building regulatory system, this is also an opportune and cost-effective time to enhance the building fire safety regulatory system as well.

The same holds true for recovery efforts that stem from building failures, such as fires and structural collapse. For example, following significant building failures in Bangladesh, one study revealed that an average of 59 noncompliance issues per factory were identified in 3,778 ready-made garment factories: 51 percent were associated with electrical safety, 30 percent with fire safety, and 19 percent with structural safety.[73] Fire safety issues received the highest prescribed urgency of remediation due to the direct danger they pose to worker safety; the most common responses were installation of fire barriers, doors, alarms, and emergency exit pathways. The identified deficiencies are all included in a comprehensive building fire safety regulatory system, along with other fire safety measures. By querying the building fire safety regulatory system — which includes planning, building and fire prevention legislation, and regulation — the Urban Fire Regulatory Assessment and Mitigation Evaluation identifies any gaps that might exist and recommends regulatory infrastructure measures to help protect against future fire catastrophes.

3.3 Accessible, Sustainable, and Inclusive Urban Development and Built Environments

Globally, urban clusters are expanding rapidly as populations migrate to cities seeking better employment opportunities, access to medical care and other services, and increased safety. It is estimated that the pace of new construction in the next 20 years will lead to a doubling of building stocks in low- and middle-income countries, and it is expected that between 2015 and 2050 the urban built-up area will increase by a factor of 3.7.[74] Due to such rapid urbanization, densification and unsafe building practices often result. These can present significant challenges from fire safety perspective.

Rapid urbanization and expansion can be difficult to manage, as the rate of growth can be faster than expected, the employment opportunities may not exist, and the social and physical infrastructure needed to support expansion may not yet be in place. With respect to the built environment, several challenging issues may arise:

- The population may be larger than the available formal housing capacity.
- Informal construction may occur in hazardous locations, and the construction itself may pose hazards to the community.

[73] Emerging Markets Consulting for the International Labour Organization and the International Finance Corporation (2016), *Remediation Financing in Bangladesh's Ready-Made Garment Sector: An Overview;* copyright © International Labour Organization/International Finance Corporation 2016.

[74] S. Angel, et al. (2016), "Atlas of Urban Expansion."

- Mechanisms for control of formal construction may be out of sync with the types of buildings being constructed and the associated hazards (e.g., high-rise residential and office buildings being built under a framework that did not contemplate such buildings and the risks they pose to occupants if not adequately mitigated).
- Appropriate fire and emergency response capacity may not exist.

These issues are of particular concern in LMICs, where a robust building fire safety regulatory system may not have been implemented, urban environments expand without adequate oversight of formal construction, and large areas of informal construction emerge. The fire risks could be significant for all the reasons identified in previous sections. In such contexts, the Urban FRAME diagnostic can help identify pertinent issues and indicate how a robust building fire safety regulatory framework can be used to help mitigate concerns. This will be especially effective at the outset of any master planning and management of urban expansion or densification.

Furthermore, the World Bank and the World Health Organization (WHO) estimate that 80 percent of people live in LMICs and that 15 percent of the world's population have some kind of disability.[75] Effective implementation of building and urban development standards for accessibility and protection of persons with disabilities and the elderly requires policies and principles translated into actual change in the configuration of the built environment. Implementation of policies for inclusion and protection of persons with disabilities and the elderly depends significantly on the capacity and competence of building regulatory institutions. This includes provisions in the building fire safety regulatory system for safeguarding people with disability during fire events.

The Urban FRAME can be used to investigate the scope of challenges associated with providing fire safety for vulnerable populations, including children, the elderly, the impoverished, and those with a wide range of disabilities that may make it difficult or impossible for them to safeguard themselves in the event of fire. The Urban FRAME can help identify regulatory options for facilitating fire safe environments for these population groups.

3.4 Climate Change Adaptation

With the changing climate, many more parts of the world are vulnerable to new or more extreme hazards than at any time in recent history. Furthermore, those least responsible for climate change are disproportionally affected by it.[76] Prolonged drought conditions, especially in areas not previously prone to it, present a wide range of issues, including increased risk of wildland and wildland-urban interface fires, as combinations of dry conditions, hot temperatures, high winds, and lack of firefighting water can combine to create catastrophic conditions.[58,59,60] Likewise, fires following extreme storm events and flooding can be nearly impossible to fight due to reduced firefighter access resulting from downed trees and power lines, flooded streets, and more.[50]

From a building regulatory system perspective, climate adaptation generally requires adjustments in building siting, design, and construction.[77] Uncertainty regarding characteristics of these projected hazards poses a unique challenge for establishing and implementing environmental, health, and safety standards. Adaptation requires future oriented hazard mapping and calculation of expected hazard loads on structures. It is of critical importance that mechanisms for land use and building and fire regulation are established to apply knowledge and guide future investment and infrastructure development.

[75] World Health Organization and World Bank (2011), "World Report on Disability."

[76] Satterthwaite, D., Archer, D., Colenbrander, S., Dodman, D., Hardoy, J., Mitlin, D. and Patel, S. (2020). Building Resilience to Climate Change in Informal Settlements, *One Earth*, Volume 2, Issue 2, Pages 143-156, ISSN 2590-3322, https://doi.org/10.1016/j.oneear.2020.02.002.

[77] See, for example, https://climatepolicy.org/index.cfm/climatepolicy/the-basics/there-are-many-possible-policy-responses/adaptation/, https://www.gov.mb.ca/mr/plups/pdf/cca.pdf, Dubois, C., Cloutier, G., Rynning, M.K.R., Adolphe, L. and Bonhomme, M. (2016). City and Building Designers, and Climate Adaptation. *Buildings*. 2016, 6, 28; doi:10.3390/buildings6030028, Carter, J.G., Cavan, G., Connelly, A., Guy, S., Handley, J. and Kazmierczak, A. (2015). Climate change and the city: Building capacity for urban adaptation, *Progress in Planning*, Volume 95, Pages 1-66, ISSN 0305-9006, https://doi.org/10.1016/j.progress.2013.08.001.

Protecting existing and expanding settlements from the effects of climate change in a cost-effective manner will require a dynamic regulatory approach that guides adaptation in advance of growing hazard effects. The Urban FRAME can help assess potential fire exposure resulting from climate change, identifying areas of potential increased risk and vulnerability, such as at the wildland-urban interface (WUI) and post-storm or -flood events. Investment in effective implementation of building regulations will contribute to (a) limiting expansion of disaster risk in the siting and construction of new settlements, (b) reducing disaster risk in vulnerable existing settlements, and (c) helping reduce disproportionately higher and less effective commitments of emergency and response activities.

3.5 Upgrading Informal Settlements

A characteristic of many large urban environments, particularly but not exclusively in low- and middle-income countries, are areas of informal settlements, slums, shantytowns, favelas, and ghettos. According to UN-Habitat, about one-third of the urban population — a total of about one billion people — live in such areas, and their numbers continue to grow. These areas often develop as a result of socioeconomic inequality and an absence of social policies to support those at the lowest economic level. Others have emerged as a consequence of the high influx of refugees or internally displaced persons (IDPs) seeking safety from war, famine, climate-change-related natural hazards and other events, or those in search of gateways to markets, employment opportunities, and access to urban services. More such environments might be expected in the near future as urban environments expand more quickly than the social, economic, and physical infrastructure can support.

The problem is not simply one of large numbers of people, and solutions will require having legal, social, technical, and economic frameworks in place — as well as the political will — to support a growing population at a socially acceptable level. Good governance regarding building location, design, construction, materials, safety, and sanitation is critical in this regard. For informal settlements, the Urban FRAME can help in assessing the ability of the building fire safety regulatory system to respond to the jurisdiction's specific needs and develop appropriate incremental levels of planning, building fire regulation, and emergency response capabilities to increase occupants' levels of health, safety, and welfare.

Figure 23: Informal settlement dwellers moving possessions to safe grounds during a fire, South Africa, 2018

Source: Justin Sullivan, 2018.

In some situations, desired safety mitigation measures are not feasible over the medium or even long term. Difficulties arise in some informal settlements because they are established environments and residents may be unwilling to give up part of what little land they own to further wholesale regulated upgrading measures, such as increasing the width of roads for fire trucks, eliminating combustible building materials, providing adequate building separation to limit fire spread, and providing for escape routes. The Urban FRAME can help identify such areas and issues, including those settlements or parts of settlements most at risk, and then help prioritize roll-out of better targeted mitigation measures. It can also help to identify where incremental change can be effective, such as by providing support for fire detection devices, local fire control equipment, training, means of communicating in emergencies, and the like. Such measures have been used in high-income countries, such as Japan, to protect dense areas of wooden buildings, as well as in informal settlements in South Africa and elsewhere.

3.6 Protecting Cultural Heritage

Existing buildings, whether several decades or several centuries old, present a wide range of fire safety challenges, including protecting structures, artifacts, and occupants or visitors. This can be particularly true for designated cultural heritage sites, where the intent is to protect the historic fabric of the building from destructive change while providing safe access to the visiting public.

While many historically significant buildings have stood the test of time, showing resiliency against a wide range of hazard events, fire remains a challenge, and many historic buildings have been affected by fire at some point in their histories. However, if existing fire safety measures are inadequate, catastrophic destruction can occur. All countries face this challenge: Such fires have occurred at the National Museum of Brazil, Notre Dame Cathedral in Paris, the Shuri Temple in Japan, and the 17th-century Wangdue Phodrang Temple in Bhutan.

In some countries, specific regulatory mechanisms and instruments have been implemented to address the needs of existing buildings and heritage buildings, including specific fire safety codes,[78] engineering approaches for risk mitigation, and risk management and mitigation strategies.[79] The Urban FRAME can help identify aspects of a building fire safety regulatory framework that respond to the specific needs of existing and historic buildings and can provide recommendations for enhancing the regulatory system to address fire safety challenges.

Figure 24: Notre-Dame de Paris Cathedral fire, Paris, France, 2019

Source: Godefroy, Paris, 2019.

Figure 25: Shuri Castle fire, Okinawa, Japan, 2019

Source: UNESCO, 2019.

[78] NFPA 914 (2019), *Code for the Protection of Historic Structures* (Quincy, MA: NFPA).
[79] For example, see www.worldbank.org/en/news/feature/2016/08/08/supporting-lebanons-cultural-heritage-as-a-driver-of-job-creation-and-local-economic-development and www.worldbank.org/en/news/feature/2016/12/22/cultural-heritage-project-strengthens-economic-community-activity-in-lebanon.

In addition, by going through the Urban FRAME process, nonregulatory guidance, such as that produced by UNESCO, ICOMOS (International Council on Monuments and Sites), and others,[80] can be identified and applied as part of the fire risk mitigation effort for cultural heritage buildings.

Case Study 8: Kenya

Fire in informal Settlements, Nairobi, Kenya

The lack of planning and access to water services and infrastructure in informal settlements exacerbates both the probability of fire and its potential for destruction. Nairobi has an estimated 2.5 million slum dwellers, approximately 60 percent of its population, living in overcrowded housing on just 5 percent of its land. On January 28, 2018, a fire engulfed the entirety of the Kijiji slum in Nairobi's Lang'ata neighborhood. The blaze left five people dead and an estimated 6,000 people homeless. Between January and March 2011, an estimated 25,000 people were displaced from fires that swept through Nairobi's informal settlements. Lack of planning in informal settlements increases the risk and intensity of fires. With crammed-together constructions and a lack of access roads and water infrastructure, firefighters struggle to contain fires and other emergencies in these areas.

Sources: Kibera, Kibera Facts & Information, https://www.kibera.org.uk/facts-info//; Northeastern University, Global Resilience Institute; "Five Killed and Thousands Displaced After Fire Rips Through Kijiji Slum in Nairobi," https://globalresilience.northeastern.edu/five-killed-and-thousands-displaced-after-fire-rips-through-kijiji-slum-in-nairobi//; The New Humanitarian (2011), "Slum Fires Highlight Urban Preparedness Gap," https://www.thenewhumanitarian.org/feature/2011/04/15/slum-fires-highlight-urban-preparedness-gap/; *Guardian* (2011), "Pipeline Fire Kills Dozens in Nairobi Slum," https://www.theguardian.com/world/2011/sep/12/pipeline-fire-nairobi-slum.

[80] For example, see https://fireriskheritage.net/ (accessed September 2020).

4.0 SCREENING QUESTIONS AND REQUIRED INFORMATION

This section identifies the information important to the Urban FRAME. The questions discussed reflect key data to be collected and the commentary indicates why it is important. In collecting this information, more than verbal or summary written communication should be obtained; verification of such communications should be made on site (e.g., check if laws exist, obtain copies of building and/or fire regulations, verify that documents referenced are available on building officials' desks for review, confirm that referenced documents are in fact used, undertake actual staff head counts, and so on).

4.1. Legal and Administrative

This first component of the Urban FRAME focuses on identifying whether the necessary **legal and administrative structure** is in place to implement and support a comprehensive building fire regulatory system framework. Note that provisions may be contained within different sets of legislation and regulations. For example, the range of regulatory provisions for building fire safety may be:

(a) Largely consolidated into *building* legislation and regulation, which all sit under a single ministry (department or agency), such as the Ministry of Construction (or similar), or

(b) Largely separated between *building* legislation and regulation that sits under a Ministry of Construction (or similar); *fire service* (fire prevention) legislation and regulations, under a Ministry of Public Safety (or similar); and *urban planning*, under a Ministry of Development (or similar).

When the provisions are split between legislative responsibilities, particularly "building" and "fire prevention." it is typical that the ***active systems*** (e.g., detection, water base suppression, firefighting facilities, etc.) are under **fire legislation**, with passive systems (e.g., egress requirements, fire resistance requirements) under the **building legislation**. Smoke control could be present in either system. However, this is not always the case. Also, formal regulatory systems are often separated into domestic housing, other residential building, and other types of occupancy. Informal settlements may or may not be addressed in formal regulation.

Potential Informants and Sources of Information

Identifying pertinent informants and information is critical to a comprehensive Urban FRAME assessment. As part of the *legal and administrative* review, the following sources should be considered:

- Texts of legislation and laws related to building and fire regulation should be obtained if available.
- Outreach to key persons in the ministries responsible for **enabling legislation** will be necessary. This could include Ministry of Construction, Civil Defense, Ministry of Economic Development, Ministry of Public Safety, and/or other related entities. In national (unitary) legislative framework countries, two or more ministries may share responsibility in cases where **building legislation** and **fire legislation** are under separate parts of government. In federal frameworks, outreach will be necessary to persons at each level of government, as appropriate to the project objectives.
- Consultation with local experts in construction law, fire prevention, and parties active in the construction sector, including building professionals, contractors, and owners, may be

necessary to understand the actual functioning of the legal process.

- It will also be helpful to consult with the local community, particularly in informal settlements. In many cases, informal sector communities may have developed their own fire prevention strategies, from rudimentary tools to control fires on roofs to evacuation plans in cases of emergency.

Screening Questions

Note: Information and data that may be available from a BRCA, if conducted, is highlighted in blue.

	Questions	*Why This Is Important*
4.1.1	Please identify all **ministries (departments/ agencies)** that have some responsibility for legislating and regulating the components within the building fire safety regulatory system. If multiple ministries (departments/agencies) have responsibilities, identify the building fire safety responsibilities of each.	*Building fire safety requirements reflect a wide range of building systems, some of which are part of the structure (e.g., structural systems, stairs, corridor walls, etc.), and others are "active" fire protection systems, such as fire detectors, sprinklers, hydrants (standpipes), firefighting water supply, etc.). In a broad sense, they also encompass electrical installations (control of ignition) and storage of hazardous/combustible/flammable materials. Requirements may legislated and regulated by a* ***single*** *branch of government (e.g., Ministry of Construction) or by* ***separate*** *branches of government (e.g., Ministry of Construction (buildings, structural focus) and Ministry of Interior, Public Safety, or other (with responsibilities for fire and emergency response), Ministry of Infrastructure (for electricity, electrical installations, firefighting water infrastructure), etc.). It is important to determine what branch(es) of government have responsibility across the breadth of building fire safety systems.*
4.1.2	Which **acts, decrees, laws,** or similar enable the regulation of the following? (a) Fire and life safety provisions within buildings (b) Fire prevention/control and/or the fire service (c) Hazardous material control (d) Electrical infrastructure associated with buildings (power to and within buildings) (e) Roadway planning and layout (e.g., for assessing fire service access and occupant evacuation) (f) Water supply, storage, and distribution for firefighting	*It is important to identify whether the fundamental enabling legislation for all aspects of the building fire safety regulatory system is in place. This includes control for ignition sources, hazardous material storage, safety of building occupants, prevention of fire spread, fire service response, and related issues. Obtaining texts of the relevant legislation is necessary for the assessment.*

4.1.3

Within which **regulations**[81] can provisions addressing the following items be found?

(a) Controls on electrical ignition hazards
(b) Controls on heating appliances
(c) Controls on fuel sources (e.g., natural gas, propane, fuel oil)
(d) Controls on storage/amounts of hazardous/ combustible/flammable material
(e) Egress/exit/escape provisions (e.g., occupant load, door width, stair details, travel distance, exit signs, etc.)
(f) Emergency lighting
(g) Smoke alarms (self-contained smoke detection and alarm)
(h) System-connected smoke detectors and/or heat detectors
(i) Fire notification appliances (audible alarms and visual alarms)
(j) Voice alarm communication systems
(k) Manual fire alarm points (pull stations)
(l) Fire alarm controls panels
(m) Emergency power
(n) Smoke control/exhaust/venting
(o) Structural fire resistance requirements (primary and secondary structure)
(p) Fire resistance of interior walls (including doors, openings in walls)
(q) Fire/smoke dampers in HVAC ductwork, ceiling, plenums
(r) Fire spread limitations on interior walls, ceilings and floors
(s) Fire resistance/fire protection/fire spread requirements for exterior walls (façade systems, wall systems, etc.)
(t) Building separation requirements
(u) Fire hose reels
(v) Fire extinguishers
(w) Firefighters standpipe (hydrant) system (for firefighter use)
(x) Fire sprinkler systems
(y) Firefighting water supply (to building, in building (e.g., tanks))
(z) Connections for firefighter apparatus
(aa) Special suppression/extinguishing systems (e.g., water mist, CO2, etc.)
(bb) Fire department/brigade access requirements (for apparatus, reaching the building, etc.)

Assuming the enabling legislation is in place, it is then important to understand ***which aspects of building fire safety are regulated and within which regulation(s) the specific fire safety provisions can be found****. Likewise, provisions for electricity, electrical installations, and controls on hazardous/combustible/flammable storage need to be identified. Obtaining texts of the pertinent regulations is necessary for the assessment.*

As evident from the list, numerous potential building fire safety features and systems contribute to building fire safety. These can be grouped into three fundamental categories: (1) means to prevent fires from occurring, (2) means to manage fire spread and impact, and (3) means to manage the exposed (e.g., building occupants)[82] and detect, communicate about, and extinguish fires by automatic or manual means.[83] Discussion of these categories is provided in Appendix E.

[81] Note that the term *regulation* is used to encompass the document or set of documents defining legally mandated building requirements. With respect to buildings, such documents may be referred to as Building Regulations (as in England), Building Codes (as in Australia and the United States), or Building Standards (as in Scotland), or the Building Standard Law as in Japan).
[82] NFPA 550 (2017), *Guide to the Fire Safety Concepts Tree* (Quincy, MA: NFPA).
[83] International Fire Safety Standards Common Principles, https://www.rics.org/globalassets/rics-website/media/news/news--opinion/fire-safety/ifss-cp-1st-edition.pdf (last accessed 5 October 2020).

4.1.4	What ministry, agency, department or other entity has primary responsibility for **development of regulations** for each of the provisions identified in 4.1.3 above?	*Development and promulgation of regulations may not be done by the same entity, so it is important to know the entity responsible for each function. For example,* ***development*** *may be by a private sector "model code" development organization, but promulgation is typically the responsibility of government. Here we need to know which entities are responsible for the development of the associated regulations. It will also be helpful to know if influence peddling or corruption is of concern in the client country, as this might influence regulation development.*
4.1.5	What ministry, agency, department or other entity has primary responsibility for **promulgation of regulations** for each of the provisions identified in 4.1.3 above?	*Regulation development and promulgation may not be done by the same entity, so it is important to know the entity responsible for each function. For example, development may be by a private sector "model code" development organization, but promulgation is typically the responsibility of government. Here we need to know which entities are responsible for* ***promulgating*** *the associated regulations. It will also be helpful to know if influence peddling or corruption is of concern in the client country, as this might influence regulation promulgation.*
4.1.6	Which acts, decrees, laws or similar enable the **regulation/licensing/certification** of, and define the roles of the following? (a) Architects (b) Planners (c) Engineers (d) Builders (carpenters, masons, etc.) (e) Trades (plumbers, electricians, etc.) (f) Contractors, installers, etc. (g) Building code officials (inspectors, etc.) (h) Fire code officials (inspectors, etc.) (i) Third-party reviewers (j) Operational firefighters	*The extent to which the professions and trades associated with design and construction are controlled, including minimum qualifications and competency requirements, experience, and so forth, can significantly influence the quality of construction and compliance with regulation. Identifying who is controlled by legislation, and how, is the first step in the assessment process.*
4.1.7	Which acts, decrees, laws or similar enable the **regulation/certification/testing/quality control** of the following? (a) Fire performance of building materials (steel, timber, masonry, concrete, etc.) (b) Fire performance of building products and systems (e.g., wall lining materials, doors, windows, heating appliances, lighting systems, etc.) (c) Fire protection systems (e.g., smoke detectors, heat detectors, water tanks, pipes, valves, controls, fire alarms, smoke exhaust equipment, etc.) (d) Contents or aspects of contents (e.g., materials which may be flammable, toxic, etc.)	*The extent to which construction materials and contents are controlled, in terms of quality, strength, and overall fitness for purpose, can have significantly affect ultimate safety, health, energy or other performance aspects of a building. Identifying what legislation and regulation is in place with respect to material control is important. It will also be helpful to know if corruption is of concern in the client country, as it relates to building materials.*

4.1.8	Are there "approved" laboratories, "nominated bodies," or other such government-recognized entities authorized to undertake fire performance testing, certification, approval of the above?	*Appropriately accredited and trusted laboratories to certify material fire performance and fire protection product and systems performance are essential to a robust building fire safety regulatory system.*
4.1.9	Within the legal framework of the country, which stakeholders have responsibility, accountability, and liability with respect to assuring compliance with building fire safety related legislation, and how is the responsibility and liability apportioned?	*Knowing who has liability in relation to compliance with regulations and how liability is apportioned are important to understanding the effectiveness of the regulatory framework and the measures needed to facilitate enforcement.*
4.1.10	Within the legal framework of the country, what types and forms of penalties are possible with respect to noncompliance with building-related regulations, and to what extent are such penalties levied?	*Closely related to the above, understanding what penalties are in place for noncompliance, and the extent to which they are enforced, provides insight into the effectiveness of the regulatory framework.*
4.1.11	Is legislation in place that facilitates establishing and collecting fees or levies that can be used to financially support implementation of regulations for planning, zoning, design, and construction of buildings?	*Many jurisdictions impose fees or levies on various stages of the building regulatory process, including when applying for permits to build, for plan review and approval, and for inspection and witnessing of building commissioning. The intent here is to identify the enabling legislation or regulation used to allow and govern the level of fees that can be charged.*

4.2 Document Development and Maintenance

This component of the Urban FRAME diagnostic focuses on the **regulatory documents** themselves: those documents that define or describe specific fire and life safety requirements that must be complied with, as well as how they are developed and maintained. As noted in 4.1 above, provisions may be contained in different sets of legislation and regulations. For example, the range of regulatory provisions for building fire safety may be:

Largely consolidated into building legislation and regulation, which all sit under a single ministry (department or agency), such as the Ministry of Construction (or similar), or

(a) Largely separated between *building* legislation and regulation that sits under a Ministry of Construction (or similar); *fire service* (fire prevention) legislation and regulations, under Ministry of Public Safety (or similar); and *urban planning*, under a Ministry of Development (or similar).

When the provisions are split between legislative responsibilities, particularly "building" and "fire prevention," it is typical that the *active systems* (e.g., detection, suppression systems, firefighting facilities, etc.) are under *fire legislation*, and *passive systems* (e.g., escape and fire resistance requirements) under *building legislation*. Smoke control could be present in either system. Also, there is often a separation within formal regulatory systems between domestic housing, other residential construction, and other types of occupancy. Informal settlements may or may not be addressed in formal regulation.

Potential Informants and Information Sources

Identifying pertinent informants and information is critical to a comprehensive Urban FRAME assessment. As part of the *document development and maintenance review*, the following sources should be considered:

- Identification and collection of **building regulations** and **fire regulations** will be needed.
- First contact may be made with the head of the government entity designated as having primary responsibility for development and maintenance of the **building regulations**, as well as the head of the government entity designated with primary responsibility for development and maintenance of the **fire (prevention and/or control) regulations**.
    - Within a unitary (national) government system, development of **building regulation** may be a unit of the ministry concerned with construction, urban development, or other (e.g., Ministry of Construction, Public Works, Economic Development, etc.). Some regulation related to buildings may also reside with the ministries of Health, Energy, and Environment.
    - Development of **fire (prevention and/or control) regulation** may be under a different ministry, such as that associated with public safety or police and emergency response (e.g., Civil Defense, Interior, National Police, Occupational Health and Safety, Public Safety, etc.).
- In a federal system, the responsible agencies may be equivalent to those noted above, but at a state, territory, or provincial level. In some instances, the entities may be commissions or boards (e.g., Building Regulation (Code) Commission, Board of Building Regulations, Bureau of Fire Prevention, Public Safety, etc.). This structure may also be observed at a county or municipal level.
- Occasionally, the regulatory development process may be managed by a nongovernmental organization (as in the United States) or quasi-governmental organization (as in Australia, Austria, and Canada). In such cases, the assessment

questions should be addressed to the relevant organization official.

- It is also helpful to consult with the local community, in particular in informal settlements. In many cases, communities may have developed their own fire prevention strategies, from rudimentary tools to control fires on roofs to evacuation plans in cases of emergency. These are important considerations in the assessment. See discussion in Appendix A on different legal and regulatory structures.
- Data and information may be obtained from several sources, including:
    - For *demographic data, economic data, construction data, etc.*: National Bureau of Statistics, Department of Commerce, Ministry of Construction
    - For *fire loss data, including annual fire loss statistics, fire service resource data (personnel, apparatus, fire stations, etc.*: Civil Defense, Department of Public Safety, National Fire Protection Agency
    - *For internationally reported fire data*: WHO (data on deaths due to burns), etc.

Screening Questions

Note: Information and data that may be available from a BRCA, if conducted, is highlighted in blue.

	Questions	*Why This Is Important*
4.2.1	Is fire hazard/risk data being used to inform building fire safety regulatory policy? If so, what are the sources of the fire hazard/risk data being used?	*Hazard and risk data, as used in regulations, must come from a credible source, such as a relevant government ministry, agency, etc., in the project country. It is important to understand the level of institutionalization (e.g., research program, or fixed bureau/agency) of these sources, and mechanisms/frequency of updating, especially exposure and fragility information. Data can include fire loss statistics, fire mortality statistics, hazardous/combustible/flammable materials locations and limits, etc.*
4.2.2	Do the formal regulations (codes) governing building fire safety have specific provisions or separate regulations (codes) for indigenous, “non-engineered” and/or “informal” construction (buildings)? By formal we mean codes, etc., adopted by law and enforceable, not simply used as guidance.	*In LMICs, building codes, if they exist, may not include provisions related to indigenous, “non-engineered” and/or “informal” construction. Significant vulnerability resides in the buildings of the “informal” sector, in particular, so having this information is critical to investment decisions. Texts of regulations will be needed.*
4.2.3	What ministry, agency, department or other entity has primary responsibility for **development and maintenance** (updates, revisions) of regulations for the following (note: same as question 4.1.3 above; there is no need to duplicate if responses were noted there)? a) Controls on electrical ignition hazards b) Controls on heating appliances c) Controls on fuel sources (e.g., natural gas, propane, fuel oil)	*The extent to which a building and fire regulations comprehensively address the wide range of fire and life safety issues will directly relate to the effectiveness of the regulations in mitigating health, safety, and welfare vulnerabilities, and/or enhancing sustainability and resiliency objectives. If a robust building regulation and supporting infrastructure, including controls on electricity and electrical installations, controls on hazardous/combustible/flammable materials,*

	d) Controls on storage/amounts of hazardous/combustible/flammable material e) Egress/exit/escape provisions (e.g., occupant load, door width, stair details, travel distance, exit signs, etc.) f) Emergency lighting g) Smoke alarms (self-contained smoke detection and alarm) h) System-connected smoke detectors and/or heat detectors i) Fire notification appliances (audible alarms and visual alarms) j) Voice alarm communication systems k) Manual fire alarm points (pull stations) l) Fire alarm controls panels m) Emergency power n) Smoke control/exhaust/venting o) Structural fire resistance requirements (primary and secondary structure) p) Fire resistance of interior walls (including doors, openings in walls) q) Fire/smoke dampers in HVAC ductwork, ceiling, plenums r) Fire spread limitations on interior walls, ceilings and floors s) Fire resistance/fire protection/fire spread requirements for exterior walls (façade systems, wall systems, etc.) t) Building separation requirements u) Fire hose reels v) Fire extinguishers w) Firefighters standpipe (hydrant) system (for firefighter use) x) Fire sprinkler systems y) Firefighting water supply (to building, in building (e.g., tanks)) z) Connections for firefighter apparatus aa) Special suppression/extinguishing systems (e.g., water mist, CO2, etc.) bb) Fire department/brigade access requirements (for apparatus, reaching the building, etc.)	*firefighting water infrastructure, etc., is not in place, significant questions may arise as to the quality of buildings and the performance they deliver. If a robust building regulation is not in place, investment will be needed to put a framework into place before construction or rebuilding to help assure objectives for buildings are met.*
4.2.4	With respect to required fire performance of material (e.g., combustibility, flame spread, smoke production, fire resistance, etc.): (a) what nationally or internationally recognized consensus standards,[84] cited by reference, specify required material fire properties and performance (e.g., fire resistance, flame spread	*Fire performance of materials is important to understand when controlling for fire and smoke spread from construction materials and determining resistance to fire expectations for different materials (e.g., brick, concrete, steel, timber). To establish performance, it is important to have a robust set of testing or performance*

[84] As used here, a *consensus standard* is a standard, developed by an accredited standards-making organization (e.g., the International Organization for Standardization (ISO)), which is required to have a "balanced" committee of varied interests participate and reach consensus on the content. Consensus requires that all views and objections be considered and that an effort be made toward their resolution.

	index, smoke produced index, etc.), and (b) are accredited test laboratories locally available to accredit fire performance of materials? If the answer to (b) is no, how are fire performance of materials and fire protection systems accredited, approved, or determined to be appropriate?	*standards against which to the assess materials and products. These consensus standards should be referenced or cited in the regulations (thus sometimes referred to as reference standards). These may be developed by nationally recognized standards development organizations (SDOs), such as the country's National Bureau of Standards or by the National Fire Protection Association (NFPA) in the United States; by regional SDOs, such as the European Committee for Normalization (CEN); or by international SDOs, such as the International Organization for Standardization (ISO). Having a robust set of recognized consensus or reference standards is essential to assuring quality of building construction. Likewise, it is important that local, accredited, and trusted laboratories exist to certify materials against the fire performance requirements. If local laboratories do not exist, other means to verify compliance with appropriate test and performance standards are needed.*
4.2.5	If unregulated, informal construction exists in informal settlements, what are the primary building materials?	*The construction type and materials can vary by countries; e.g., construction in African cities is very different from that in South America. Different materials pose different risks (e.g., combustible materials have higher risk of burning, causing fire-related impacts on occupants).*
4.2.6	With respect to fire protection system performance requirements: (a) what nationally or internationally recognized consensus standards, which establish system performance, operability, design, installation, test, and maintenance requirements, are referenced, and (b) are accredited test laboratories locally available to accredit materials, products, and systems? If the answer to (b) is no, how are fire performance of materials and fire protection systems accredited, approved, or determined to be appropriate?	*Performance and quality of fire protection equipment and systems and electrical infrastructure, systems, and components must deliver on expectations of reliability and availability to operate when needed. To establish performance, it is important to have a robust set of test or performance standards against which to assess products and systems. These consensus standards should be referenced or cited in the regulations (thus sometimes referred to as reference standards). These may be developed by nationally recognized standards development organizations (SDOs), such as the country's National Bureau of Standards, or the National Fire Protection Association (NFPA) in the United States or the British Standards Institute (BSI) in England; by regional SDOs, such as the European Committee for Normalization (CEN); or by international SDOs, such as the International Organization for Standardization (ISO). Having a robust set of recognized consensus or reference standards is essential to assuring quality of fire protection system quality and performance. Likewise, it is important that local, accredited, and trusted laboratories exist to certify products and systems to the performance requirements. If local laboratories do not exist, other means to verify*

		compliance with appropriate test and performance standards will be needed.
4.2.7	For which of the following building use or occupancy classifications are there specific fire and life safety provisions (e.g., egress system, fire resistance rating, fire detection and alarm requirements, etc.)? a) Assembly spaces (restaurants, theaters, etc.) b) Businesses (offices) c) Educational (schools) d) Healthcare (hospitals, nursing homes, etc.) e) Correction and detention f) Critical infrastructure (utilities, police, etc.) g) Domestic housing (homes, apartments) h) Hotels and motels i) Dormitories, hostels, boarding houses j) Light industry k) Heavy industry l) Hazardous industry m) Light storage n) Hazardous storage o) Above and below grade parking p) Underground structures q) High-rise structures r) Small to medium shops s) Malls and large shopping complexes t) Mixed use buildings	*The extent to which building fire safety regulation comprehensively addresses the wide range fire safety issues, over the breadth of building uses (occupancy types or categories), is important in terms of understanding how health, safety, and welfare vulnerabilities are addressed for different population groups (e.g., families in dwellings, workers in a factory, patients in a hospital, the urban poor). It is also important in regard to the extent to which "high-risk" buildings (as either posing risk to the community, such as a chemical processing facility, or placing large numbers of occupants at risk, such as a space of assembly or high-rise building) have associated requirements, specific to those particular building uses.*
4.2.8	To what extent are access, use, and egress requirements for disabled and aged populations addressed within the building fire safety regulation?	*Effective implementation of building and urban development standards for accessibility and protection of persons with disabilities and the elderly requires policies and principles to be translated into actual change in the configuration of the built environment.*
4.2.9	To what extent are firefighting apparatus access, firefighter building access, firefighting equipment, and firefighter safety requirements addressed within the building fire safety regulations?	*It is not possible to adequately assess building fire safety without considering means of supporting the fire service's manual suppression activities, including access by vehicles/apparatus to get close to buildings, connections to firefighter water supplies outside and inside buildings, internal systems and equipment to support firefighting activities (e.g., standpipes, hose connections, etc.), and firefighter safety (e.g., structural resilience in case of fire).*
4.2.10	What is the number and distribution of fire stations and apparatus and the ratio of fire service personnel to the population (citywide, as well as per station)?	*Data on fire service capabilities to actually reach a fire location, with adequate operational staff and apparatus, is important for understanding the capacity of the fire service as part of the building fire safety regulatory system.*

4.3 Implementation and Capacity Building

This third component of the Urban FRAME diagnostic focuses on the implementation and management of the building fire safety regulatory regime at the level(s) of project scope and capacity building among government, industry and owners, and the community.

Potential Informants

Government

This assessment, as related to government, focuses on Planning, Building, and Fire Departments (or equivalents) and/or private sector organizations with implementation and enforcement functions.

- Within government entities, the chief official (planning, building, fire) of the jurisdiction, or CEO of a private sector entity, will typically be the principal informant, with reference to relevant subordinates when appropriate.
- It is also highly desirable to consult with relevant senior jurisdiction officials, such as mayors, city managers, related city department heads, and members of the building community, including designers, builders, developers, building owners, and contract regulatory staff. Other government entities to consult include social services for fire, health, and safety.

Industry, Owners, and Academia

In some cases, large property owners, developers, or corporations, especially offshore entities, may have their own building fire safety requirements. This is the case, for example, with many international hotel chains and large corporate manufacturing firms.

- Corporate guidelines, and insurer requirements, should be considered in these cases.

The education of professionals and skilled labor is also important, as are research and testing facilities. These may be under the government or in the private sector. Sources to contact may include:

- University programs in fire safety engineering and related disciplines
- Programs for technician and skilled labor training or apprentice development
- National and/or private sector fire or materials testing and approval laboratories

Professional bodies and other related organizations may be sources for resources and information.

- Engineering societies, industry associations, code official organizations, firefighter organizations

Community

It is also essential to reach outside traditional channels, especially in informal settlements and other unregulated areas, where traditional communication paths may be absent.

- This may be through social workers, medical professionals, or others who work with inhabitants and observe conditions and can provide helpful input and aid in facilitating change.
- Outreach to NGOs working within these communities may also be helpful.

Screening Questions: Government

Note: Information and data that may be available from a BRCA, if conducted, is highlighted in blue.

	Questions	Why This Is Important
4.3.1	If formal land-use planning, building, and fire regulations exist, are they legally promulgated and enforced throughout all areas of the country, region (state, territory, province), or city(ies) covered by the project?	*While a country may have appropriate legislation to enable pertinent regulation, that does not mean the regulations have been adopted into use throughout the entire area addressed by the project. To assess the effectiveness of the building regulatory framework, the extent of promulgation and enforcement needs to be known.*
4.3.2	If the answer to 4.3.1 is no, estimate the percentage of the country, region, or city(ies) covered by the project that does not have a set of comprehensive land-use planning, building, and fire regulations legally promulgated and enforced for all buildings. Include in this estimate any areas of indigenous, "non-engineered" and/or "informal" construction, which may be materially affected by the project, in particular disaster risk or vulnerability mitigation, disaster recovery, and urban densification projects. Estimate the percentage of buildings not currently subject to formal regulations.	*This question gets to the issue of the extent to which buildings are (or will be) subject to formal regulations on planning, zoning, design, construction, and use. If a significant portion of the building stock is somehow outside of the building fire regulatory framework (e.g., "informal" construction, shanties, etc.), a formal building regulatory framework will have limited effectiveness. Conversely, a higher level of investment in the building regulatory framework may be needed to facilitate the targeted level of fire safety and resiliency of the building stock.*
4.3.3	Are fire hazard and risk data, maps, etc., pertinent to the country, region, or city(ies) covered by the project, comprehensive, up to date, appropriately cited in the regulations, and available for use in assessing the adequacy of the regulations in helping to mitigate or avoid fire hazards and risk as part of the project?	*Related to 4.2.1 above, the presence of hazard and risk data, maps, and related information within the regulations does not assure that they are up to date and appropriate to the needs of the project, especially for fire risk and vulnerability mitigation. It also does not assure that sufficient technical capacity is available to properly apply and use hazard and risk information in decision-making. This is especially true with respect to projected future hazards and mitigation needs relating to climate change.*
4.3.4	What is the recent (e.g., five-year) fire loss history in the country, region, or city of concern (i.e., fatalities, injuries, number of fires, types of building fires, wildland-urban interface fires, etc.)?	*The range of natural and technological fire hazards that can be expected to impact the building stock affected by a project should be well understood for all geographic regions addressed by the project.*
4.3.5	What are the ten-year historical and ten-year projected number of formal building projects — new construction, renovation, expansion, etc.	*Aside from having legislation and regulations in place, building regulatory capacity is largely a function of how many projects are being controlled*

	— for the country, region, or city(ies) covered by the project?	*and how many people are involved in the regulatory control of those projects. This question provides benchmarking data on the historical and projected volume of construction.*
4.3.6	How many Building and/or Fire Departments (or equivalent) are staffed full-time in the country, region, or city(ies) covered by the project? How many full-time staff are employed in each department in the relevant geographic area (i.e., country, region, or city(ies) covered by the project), and what are their salary levels? If contractors are used in support of full-time staff, what how many contractors are employed, by department and geographic area?	*The best, most up to date, and comprehensive set of building fire safety legislation and regulations will only be effective if they are implemented and adequately enforced. While neither the only nor a complete measure, obtaining a count of the total number of relevant departments and of the full-time staff working in each relevant department — for all relevant areas of the country — can provide insight on capacity and quality. This is especially true where rapid urban expansion is taking place, and the need for large staff numbers exists due to the volume of construction.*
4.3.7	What is the number of staff and, where applicable, contractors in each Building and/or Fire Department (or equivalent), who are responsible for reviewing / approving / inspecting building fire safety, electrical installations, and hazardous materials compliance, in the country, region, or city(ies) covered by the project, with respect to the following? a) Issuing permits, and for what (e.g., building construction, system installation (electrical, mechanical, fire protection), etc.) b) Plan or drawing review and approval c) Calculation verification d) Site inspection, for what projects (e.g., all, large, etc.), for what items (e.g., materials, fire protection systems, etc.), and at what intervals (e.g., various stages in construction and if so when, upon completion, etc.) e) Witnessing tests f) Issuing certificates of occupancy g) Conducting post-occupancy compliance inspections (e.g., warranty of fitness) h) Inspecting for dangerous conditions	*Following on the above, this question aims to provide additional detail as to numbers of staff and/or contractors assigned to the key functions of building fire safety regulatory system design and construction document review and approval, site inspection, test witnessing, and the like.*
4.3.8	Identify the types, turnaround times, and frequency of review, inspection, and approval activities undertaken by relevant Building and/or Fire Departments (or equivalent) responsible for enforcing building fire safety	*Along with the numbers of building projects to be undertaken, and the staff and contractors in any given department, the number of activities that the staff must perform, and the target time allotted or required to perform those tasks, is essential*

	regulation compliance, in the country, region, or city(ies) covered by the project, with respect to the following: a) Issuing permits, and for what b) Reviewing and approving plans or drawings c) Verifying calculations d) Inspecting sites, for what projects, for what items, at what frequency e) Witnessing tests f) Issuing certificates of occupancy g) Conducting post-occupancy compliance inspections h) Inspecting for dangerous conditions	*information for capacity assessment. In some countries, very short turnaround times are mandated by law (e.g., two to four weeks for review and approval of drawings and issuing building permits), whereas in others up to a year might be expected.[85] To be efficient, an appropriate level of available time and resources is needed. Information on the documents used or referenced during the review process should be collected.*
4.3.9	What actual, verifiable qualifications are held by the full-time staff of the Building and/or Fire Departments (or equivalent, such as third parties), responsible for reviewing and approving building fire safety, electrical installations, and hazardous materials compliance, in the country, region, or city(ies) covered by the project?	*The capacity assessment rests on the qualifications as well as the numbers of staff involved in regulatory review. Use of unqualified or ill-qualified persons might "make the numbers look good" in terms of capacity, but the outcomes can be dangerous, especially when it comes to safety-related approvals (e.g., geotechnical assessments and design, structural analysis and design, fire safety design, etc.).*
4.3.10	What number of staff in each Building and/or Fire Department (or equivalent) are responsible for enforcing land-use, zoning, building and fire regulation compliance, electrical installation compliance, and hazardous materials storage compliance, in the country, region, or city(ies) covered by the project, in the following areas? a) Improper building use b) Building modification, including increase in area, height, change of use c) Improper storage of hazardous materials d) Inadequate upkeep of required safety systems (e.g., fire protection systems)	*Similar to the above line of questioning, this question seeks to understand the capacity, in numbers, of persons available for enforcement activities. In this case, we focus largely on post-occupancy enforcement, as improper use of permitted buildings, improper storage, etc., can lead to significant losses in hazard events, much more so than in compliant buildings.*
4.3.11	Identify types and frequency of enforcement activities undertaken by relevant Building and/or Fire Departments (or equivalent), responsible for enforcing building fire safety compliance, in the country, region, or city(ies) covered by the project, such as: a) Site inspection	*As with 4.3.8 above, the number of enforcement activities that staff must perform, and the target time allotted or required to perform those tasks, is essential information for capacity assessment.*

[85] For examples, see http://www.doingbusiness.org/data/exploretopics/dealing-with-construction-permits.

	b) Building inspection c) Stop-work orders d) Stop-use of building orders	
4.3.12	What actual, verifiable qualifications are held by staff of the Building and/or Fire Departments (or equivalent), who are responsible for enforcing building fire safety compliance, electrical installation compliance, and hazardous materials storage compliance in the country, region, or city(ies) covered by the project?	*As with question 4.3.10 above, capacity assessment rests on the qualifications as well as the numbers of staff involved in regulatory enforcement. Use of unqualified or ill-qualified persons might "make the numbers look good" in terms of capacity, but the outcomes can be dangerous, especially when it comes to inspecting safety-related issues in operational buildings.*

Screening Questions: Industry, Owners, and Academia

Note: Information and data that may be available from a BRCA, if conducted, is highlighted in blue.

	Questions	*Why This Is Important*
4.3.13	In the case that a large property owner, developer, or corporation, including offshore entities, and/or their insurers, have their own building fire safety requirements, how are these requirements considered in building fire safety approvals, if at all?	*There can sometimes be conflicts between the building fire safety regulatory requirements of a jurisdiction and those of a private firm and/or its insurer. Often, but not always, the corporate and/or insurer requirements can be more restrictive (requiring greater safety). However, care should be taken to meet all local requirements, so understanding how any conflict is addressed in reviews and approvals, if at all, is important.*
4.3.14	To what extent do insurance companies offering fire insurance operate in the country, and do they have fire loss data that can be shared?	*The insurance sector often has fire loss data. In many cases, these data are proprietary; however, it may be possible to obtain some helpful data from the insurance sector.*
4.1.15	Are any "approved" or "accredited" laboratories, "nominated bodies," or other such government-recognized entities authorized to undertake fire performance testing, certification, and approval of materials and systems?	*Appropriately accredited and trusted laboratories to certify fire performance of fire protection materials, products, and systems is essential to robust building fire safety regulatory systems. Such laboratories may be government operated, in the private sector, or both.*
4.3.16	To what extent do formal university programs in fire safety engineering exist, and how do they prepare engineering, design, and regulatory professionals? That is, where such programs exist, where are they, what are their curricula, and do they educate students from all sectors?	*For building fire safety regulatory systems to work well, they require suitably educated engineers, design professionals, and regulatory officials in fire safety engineering analysis and design.*
4.2.17	To what extent do educational programs and curricula addressing design, installation, inspection, and maintenance of fire safety systems exist in formal education and continuing professional development programs for technicians, skilled laborers, fire service personnel, and related non-engineering professionals? What different types of trainings and capacity-building programs are available (course titles, content)? Are they carried out by the government, associations of engineers/architects, or other training institutions, and what level of expertise do the educators have in the topic areas? Are there any platforms / organizations that can be leveraged	*For building fire safety regulatory systems to work well, they require properly trained technicians, inspectors, and skilled laborers (i.e., tradespersons, such as electricians), across the design, approval, installation, and inspection spectrum. To effectively foster the required capacity in the industry, it is important to leverage associations of building professionals and companies associated with construction, as well as educational institutions and vocational training facilities. Some of these groups may have online training portals or other mechanisms that can be useful for training as well as for dissemination of information.*

	for effective education and information dissemination?	
4.2.18	To what extent do educational programs and curricula exist that provide formal education, skills training, and continuing professional development for fire service personnel (i.e., a Fire Academy or Fire Services College)?	*To support the fire prevention and operational firefighting aspects of the building fire safety regulatory system, properly trained firefighters and emergency responders are needed.*

Screening Questions: Community

Note: Information and data that may be available from a BRCA, if conducted, is highlighted in blue.

	Questions	*Why This Is Important*
4.3.19	Are there government social services ministries, departments, or groups or non-governmental organizations or social entrepreneurs working with communities and individuals on managing fire hazards and risks within their homes and/or communities?	*Even if building fire safety regulation exists, there is significant scope for local awareness training and capacity building for fire risk reduction. Such efforts can come from social services, the fire service, NGOs, social entrepreneurs, or other organizations or agencies working with the local community to implement fire safety measures. Capturing these services and their impact is important to the assessment.*
4.3.20	If there are government social services ministries, departments or groups, NGOs, or social entrepreneurs working with communities and individuals on managing fire hazards and risks, what types of data do they have on fire hazards and risks in their community? This could include: • building material type • building density • evacuation paths • fire sources and history • road and water accessibility • fire services accessibility Such local data can be used to generate fire risk maps in the absence of formal data from government.	*Community-based participatory risk and vulnerability assessments and planning have been widely used in disaster risk management programing worldwide in recent years.*[86] *Participatory capacity and vulnerability assessment (PCVA) is a systematic way of understanding and analyzing the capacity and vulnerability of communities, and distinct groups within communities, to climate change and disaster risks. Engaging with the community is important to both understand residents' needs and to inform policies to address them. Although these assessments take many different approaches and forms, they all seek to identify and assess the hazards and risks people face in their locality, their vulnerability and resilience to those risks, and their capacity to manage them.*[87]
4.3.21	If there are government social services ministries, departments, or groups, NGOs, or social entrepreneurs working with communities and individuals on managing fire hazards and risks, what types of fire risk reduction strategies are they working to implement at the household and at the community level?	*A number of mitigation activities can be undertaken at the household and at the community level. These range from fire services or NGOs distributing smoke alarms to community fire planning, and more. It is essential to capture any that are in use and to consider whether those not in use can be options going forward. This applies in all situations, but in particular to informal settlements.* [88]

[86] See, for example, https://unfccc.int/files/adaptation/cancun_adaptation_framework/adaptation_committee/application/pdf/pcva_toolkit_oxfam_australia.pdf; D. Van Niekerk, L.D. Nemakonde, L. Kruger, and K. Forbes-Genade (2018), "Community-Based Disaster Risk Management," in *Handbook of Disaster Research*, ed. H. Rodríguez, W. Donner, and J. Trainor, Handbooks of Sociology and Social Research (Springer, Cham), https://doi.org/10.1007/978-3-319-63254-4_20; https://oxfamilibrary.openrepository.com/bitstream/handle/10546/232411/ml-participatory-capacity-vulnerability-analysis-practitioners-guide-010612-en.pdf;jsessionid=BB3896CB1DE0DF5D0A7D632B206B5C55?sequence=4.
[87] John Twigg, Nicola Christie, James Haworth, Emmanuel Osuteye, and Artemis Skarlatidou (2017), "Improved Methods for Fire Risk Assessment in Low-Income and Informal Settlements," *Int. J. Environ. Res. Public Health* 14 (139); doi:10.3390/ijerph14020139.
[88] Arup, *A Framework for Fire Safety in Informal Settlements* (2018), London.

4.3.22	If there are government social services ministries, departments, or groups, NGOs, or social entrepreneurs working with communities and individuals on emergency preparedness, what types of strategies are they working to implement at the household level or at the community level?	*A number of preparedness activities can be undertaken at the household or community level, including escape and evacuation planning for homes and neighborhoods. It is essential to capture any that are in use and to consider whether those not in use can be options going forward. This applies in all situations but is particularly helpful for informal settlements.*[84]
4.3.23	What types of capacity-building strategies are government, NGOs, and communities working to implement at the city level?	*A key aspect of resiliency is having the capacity to absorb events, respond, and recover. This includes society's capacity, at the individual, community, and city level, to mitigate immediate impacts and support recovery. It is important to capture any such efforts underway and any actors involved those efforts.*
4.3.24	To what extent are building fire safety regulations used as educational tools for describing the benefit of regulation, if formal regulation is applied to any informal sectors that exist in the country, region, or city(ies) covered by the project?	*It is helpful to discuss with occupants of informal settlements the benefits of having a formal building fire safety regulatory system, and to get their feedback on such systems, if they are to be applied to current areas of informal development. This discussion may be through social networks outside traditional channels, especially within informal settlements or areas where traditional communication paths may be absent.*
4.3.25	Do educational curricula exist regarding the structure, content, and use of building fire safety regulation that can be used as a basis of outreach to the informal sector?	*In addition to having a well-educated and trained workforce, it is also essential to disseminate information on the benefits of the building regulatory system via social networks outside of traditional channels, especially within informal settlements and other unregulated areas where traditional communication paths may be absent.*

5.0 SUMMARY OUTCOMES

The answers to the questions posed in Section 4 provide data and information that can help inform investment decisions aimed at enhancing building fire safety regulatory system capacity. To quickly summarize the information obtained and to get a sense of the magnitude of the need, the following largely "yes"/"no" questions can be used. In brief, if most of the answers are "no," then much effort will be needed to significantly enhance the building fire safety regulatory system. If most of the answers are "yes," the areas of need are fewer and the required investment will likely be much lower. The total number of "partial" answers indicate a level of need somewhere in-between. First, summarize the **type and scope of the World Bank project under discussion** within which the Urban FRAME would be undertaken (see Section 3).

B.1.1	The project type under discussion is: a) Disaster Risk/Vulnerability Reduction b) Disaster Recovery c) Accessible, Sustainable, and Inclusive Urban Development and Built Environments d) Climate Change Adaptation e) Upgrade of Informal Settlements f) Protection of Cultural Heritage
B.1.2	The geographic project scope is: a) National b) Regional (state, territory, province within the country) c) Municipal (city level) d) Community
B.1.3	The breadth of building uses to be considered is: a) All buildings b) Specific building uses — formal construction (e.g., public buildings, housing, industrial) c) Informal housing only
B.1.4	The investment timeline is: a) Phased across short, medium, and long term b) Predominantly long term c) Predominantly medium term d) Predominantly short term

5.1 Legal and Administrative Bases for Building Fire Safety Regulations

The checklist in Section 5.1., addressing legal and administrative bases for building fire safety regulations, provides a quick snapshot of the extent of regulatory capacity building that may be needed around **enabling legislation**. Information is drawn from responses to questions in Section 4.1. Quite simply, the more enabling legislation that is in place, the fewer resources will be needed to build capacity. All "yes" responses likely mean a good legislative infrastructure is in place and investment needs are comparatively low. All "no" responses might suggest significant investment and time are needed to achieve adequate fire safety regulations.

		Yes	No	Partial
5.1.1.	**Acts, decrees, laws or similar are in place that enable the regulation of:**			
	a) Width of streets, building separation distances, zoning by predominant building type (e.g., residential, commercial, etc.)			
	b) Fire and life safety provisions within buildings			
	c) Fire service access to and equipment in buildings			
	d) Electrical systems in buildings			
	e) Controls on amounts of hazardous materials in buildings			
	f) Electricity infrastructure			
	g) Water distribution infrastructure			
5.1.2.	**Building fire safety requirements are legislated under:**			
	a) Building Act or legislation			
	b) Fire Service Act or legislation			
	c) Building and Fire Service Acts or legislation			
	d) Building and Other (e.g., Public Safety) Acts or legislation			
5.1.3.	**Acts, decrees, laws or similar are in place that enable the regulation, licensing, or certification of the following:**			
	a) Planners			
	b) Architects			
	c) Engineers			
	d) Builders or developers			
	e) Trades (carpenters, masons, plumbers, electricians, etc.)			
	f) Contractors and installers			
	g) Building code officials (building control officers)			
	h) Fire code officials (fire prevention officers)			
5.1.4.	**Acts, decrees, laws or similar are in place that enable the regulation, certification, testing, or quality control of the following:**			
	a) Building material fire performance (e.g., fire resistance rating, flame spread rating, etc.)			
	b) Fire protection systems (e.g., smoke alarms, sprinklers, etc.)			
	c) Safety aspects of contents (e.g., combustibility, flammability, toxicity)			
	d) Electrical installations in buildings			
	e) Electrical appliances in buildings			
	f) Heating and cooking appliances in buildings			

5.2 Regulations (Codes/Standards), Development, and Maintenance

Section 5.2 addresses regulations, development, and maintenance and provides a quick snapshot of the extent of regulatory capacity building that may be needed around the specific **regulations** (e.g., planning and zoning, building, fire, etc.) to facilitate building fire safety. Information is drawn from responses to questions in Section 4.2. As with the above, the more formal regulatory components pertinent to the project that are in place, the fewer capacity-building resources will be required. All "yes" responses likely mean a good regulatory infrastructure exists and investment needs will be comparatively low. All "no" responses suggest significant investment might be needed.

		Yes	No	Partial
5.2.1	**If formal building fire safety regulations exist, provisions are in:** a) Building Regulations (Code) b) Fire Prevention Regulations (Code) c) Combination Building and Fire Prevention Regulations d) Combination Building Regulation and Other			
5.2.2	**If formal building fire safety regulations exist, do they have specific provisions for indigenous, "non-engineered," and/or "informal" construction (buildings)? By *formal* we mean regulations that were adopted by law and are enforceable, not those used simply as guidance.**			
5.2.3	**If formal building fire safety regulations exist, specific provisions exist for the following:**			
	a) Controls on electrical ignition hazards b) Controls on heating appliances c) Controls on fuel sources (e.g., natural gas, propane, fuel oil) d) Controls on storage or amounts of hazardous, combustible, or flammable material e) Egress/exit/escape provisions (e.g., occupant load, door width, stair details, travel distance, exit signs, etc.) f) Emergency lighting g) Smoke alarms (self-contained smoke detection and alarm) h) System-connected smoke detectors and/or heat detectors			
	i) Fire notification appliances (audible and visual alarms) j) Voice alarm communication systems k) Manual fire alarm points (pull stations) l) Fire alarm controls panels			
	m) Emergency power n) Smoke control/exhaust/venting o) Structural fire resistance requirements (primary and secondary structure)			

	p) Fire resistance of interior walls (including doors and openings) q) Fire or smoke dampers in HVAC ductwork, ceiling, plenums			
	r) Fire spread limitations on interior walls, ceilings, and floors s) Fire resistance, fire protection, and fire spread requirements for exterior walls (façade systems, wall systems, etc.)			
	t) Building separation requirements u) Fire hose reels v) Fire extinguishers w) Firefighters standpipe (hydrant) system (for firefighter use)			
	x) Fire sprinkler systems y) Firefighting water supply (to building, in building (e.g., tanks)) z) Connections for firefighter apparatus aa) Special suppression or extinguishing systems (e.g., water mist, CO2, etc.) bb) Fire department or brigade access requirements (for apparatus, reaching the building, etc.)			
5.2.4	**If formal building and fire regulations exist, do they require, by reference, the use of nationally or internationally recognized *consensus standards* specifying the following:**			
	a) Required material properties and performance (e.g., fire resistance, smoke spread rating, etc.)			
	b) Required system features, functions, and performance (e.g., alarm systems, sprinkler systems, etc.)			
	c) Requirements for certification of building and safety products, components, systems, and assemblies to recognized standards			
	d) Requirements for design, installation, commissioning, inspection, testing, and maintenance of systems			

5.3 Implementation and Capacity Building

Section 5.3 addresses implementation and capacity building, providing a snapshot of the extent to which the **systems, documents, and appropriately educated and trained people** are in place to facilitate the building fire safety regulatory system. Information is drawn from responses to questions in Section 4.3. The extent of informal construction and numbers of qualified personnel are likely to be significant drivers of investment needs.

		Yes	No	Partial
5.3.1	Are formal land-use building fire safety regulations legally promulgated and enforced throughout all areas of the country, region (state, territory, province), or city(ies)?			
		>80%	50% - 80%	< 50%
5.3.2	If the answer to 5.4.1 is "no," indicate the estimated percentage of the country, region, or city covered by the project that does not have a set of comprehensive building fire safety regulations legally promulgated and enforced for all buildings. Include in this estimate any areas of indigenous, "non-engineered," and/or "informal" construction that may be materially affected by the project, in particular those concerning disaster risk/vulnerability mitigation, disaster recovery, and urban densification projects. Estimate the percentage of buildings not currently subject to formal regulations.			
		Yes	No	Partial
5.3.3	Are the fire loss data, maps, etc., pertinent to the country, region, or city(ies) covered by the project comprehensive, current, and appropriately cited in the regulations and available for use in assessing the adequacy of the regulations in helping to mitigate or avoid fire hazards or risks as part of the project?			
5.3.4	Is the number of full-time staff adequate in Building Departments and Fire Departments in the geographic region of importance to the project?			
5.3.5	For the Building Departments and Fire Departments that do exist, are they adequately staffed in terms of numbers of suitably qualified and/or certified professionals?			
5.3.6	Is there an adequate number of university programs in fire safety engineering with suitable curricula and facilities for producing the engineering, design, and regulatory professionals with the necessary education and qualifications?			
5.3.7	Are there "approved" or "accredited" laboratories, "nominated bodies," or other such government-recognized entities authorized to undertake fire performance testing, certification, and approval of materials and systems?			

5.3.8	Is the number of education and training programs with suitable curricula and facilities adequate for producing the required technicians, tradespersons, firefighters, and related non-engineering and design professionals with the necessary training and qualifications?			
5.3.9	Are any government social services ministries, departments, or groups, NGOs, or social entrepreneurs working with communities and individuals on managing fire hazards and risks within their homes and/or communities?			
5.3.10	If any government social services ministries, departments, or groups, NGOs, or social entrepreneurs are working with communities and individuals on managing or reducing fire hazards and risks, do they have data on fire hazards and risks at the household and/or community level?			
5.3.11	If any government social services ministries, departments, or groups, NGOs, or social entrepreneurs are working with communities and individuals on emergency preparedness, do they have strategies that are implemented at the household or community level?			
5.3.12	If any government social services ministries, departments, or groups, NGOs, or social entrepreneurs are working with communities and individuals on response during a fire, do they have strategies implemented at the household or community level?			
5.3.13	Are the government ministries, departments, or groups, NGOs, and communities working to implement any capacity-building strategies at the city level?			

5.4 Concluding Remarks

The Urban FRAME diagnostic was designed to support government officials, project managers, and World Bank TTLs to identify critical gaps in fire safety aspects of a building regulatory system. It also acknowledges the multifaceted nature of fire safety regulations and the different levels of expertise that can be found in any given context. By providing a knowledge baseline, the Urban FRAME support helps determine the relative completeness of the building fire safety regulatory and infrastructure systems and the likelihood of advancing project objectives as is or with enhancements in core areas. Several potential opportunities exist for integrating the outcomes from an Urban FRAME assessment into projects ongoing in a jurisdiction. For example, a significant building and/or infrastructure resilience program to increase seismic resilience of buildings and critical infrastructure creates an opportunity to address building and fire regulatory issues identified through a BRCA and/or an Urban FRAME assessment.

The Urban FRAME diagnostic can serve as a methodology for preliminary findings on the status of the building fire safety regulatory environment. These findings can be communicated to stakeholders or other relevant parties in the form of recommendations that can have a substantial impact on the medium- and long-term planning of an articulated fire regulatory system.

Appendix A: Terms of Reference for Urban FRAME

Specific terms of reference (TOR) must be developed for each opportunity. The type of engagement will dictate specific policy and technical needs. The following serves as a template for identification of specific contract skills and expertise by building regulatory framework component.

Specific Tasks and Deliverables

The deliverable will be a comprehensive Urban FRAME report assessing local building fire safety regulatory capacity following the Urban FRAME methodology, highlighting gaps in the existing building fire safety regulatory framework, and providing the necessary information to develop a baseline for formulating technical assistance to the [insert city/country]. Findings drawn can be used to determine areas for improvement and future investment for the World Bank and other international financial institutions. The Urban FRAME report will include detailed recommendations and a PowerPoint (PPT) presentation outlining the key findings to inform follow-up policy dialogue.

Estimated time commitments are as follows. This should be considered a guide and modified as necessary to the specific program needs.

Activity	Estimated Time
1. Conducting desk research on legislation, regulation, and information and data sources and identifying and reaching out to potential informants. Initiating Urban FRAME using available information.	2–4 weeks: 2 persons (depending on scope)
Expected field trip	
2. Conduct meetings with key actors across appropriate government, private sector, and community entities as identified in the Urban FRAME diagnostic. Compile additional data and information. View representative parts of the city/country as reflective of the project scope, including formal and informal construction or residential, public, and critical infrastructure use.	2 weeks: 2–4 persons (depending on scope)
3. Develop draft report that follows on the interim report's findings.	2 weeks: 2–4 persons (depending on scope)
Expected field trip	
4. Review and discuss draft report with key stakeholders. Collect any additional information deemed pertinent.	1 week: 2 persons (depending on scope)
5. Finalize report with the full extent of the findings and processes developed in the draft report.	1 week: 2 persons (depending on scope)

The overall time required is estimated as between 80 and 120 days. If a BRCA and record to report (R2R) have been conducted, the amount of time required will likely be at the lower end. If these assessments and associated data are not available, the time required and number of persons involved will likely be at the higher end (with more and/or broader expertise needed).

Detailed outputs and deliverables will be agreed with the Task Team Leader and will include:

Deliverable	Scheduled Delivery
1. Inception report outlining the team's proposed approach.	
Expected field trip	
2. Interim report, including initial findings from the mission, responses to all relevant questions contained in the Urban FRAME assessment methodology, and any additional questions from the consultant.	
3. Draft report that follows on the interim report's findings.	
Expected field trip	
4. Final report with the full extent of the findings and processes developed in the draft report.	
5. PPT presentation of key findings to present to clients and partners.	

The expected field trips listed in the table above provide an initial outline for the TOR and could be confirmed and/or agreed upon with the BRR team once the firm's proposed plan of action is discussed.

Qualification Requirements of Firm, Institution, and/or Individual Consultants

This assignment is to be carried out by a single entity or a consortium with the recommended mix of expertise. In all cases, the contracted entity will carry responsibility for providing personnel with the requisite qualifications and experience, conducting the Urban FRAME diagnostic, and delivering its corresponding report.

The contracted entity must be able to demonstrate its experience and capacity, in terms of qualified persons, to undertake the assignment.

This assignment is to be carried out by consultants with complementary sets of skills and background experience. It will require a Senior Policy and Regulatory Development Specialist and a Senior Built Environment Specialist, preferably with a relevant technical and engineering background. A detailed description of preferred qualifications is provided below.

Component 1 — Legal and Administrative (may not be needed if BRCA already exists)

Policy Expertise
At this level, it is recommended that the project include someone with a legal or other regulatory background who understands legislative processes and has experience interacting with senior politicians and policy makers, such as legislative members, ministers, agency or department directors, and so forth. This is particularly important if the legal and administrative frameworks necessary to support building and fire regulations are not in place.

Technical Expertise
At this level, technical expertise may focus on issues of economics, finance, and risk in terms of being able to support economic impact analysis, benefit-cost analysis, and so on, as related to impacts of regulation and markets.

Component 2 — Regulatory Development and Structure (essential for all Urban FRAME)

Policy Expertise
The ideal qualifications and expertise to facilitate policy-level assessment of this component includes either (i) an engineering, architecture, or building control degree, with experience serving as head of a building or fire

regulatory development agency or organization, or (ii) lengthy service in the development of building fire safety regulations, codes, and standards. The candidate should have served at least 10 years in a lead management or administrative role with responsibilities for developing regulations, consulting with industry and the public, and promulgating regulations. The experience may come from the national, regional, or local level.

Technical Expertise

Input from fire protection engineers (fire safety engineers) on building fire safety design requirements is fundamental. This will be important for assessing the capacity of regulations concerning fire mitigation strategies such as fire detection, fire suppression, smoke control, fire performance of structure (structural system, compartment barriers, doors, walls, etc.), egress systems, elevator systems, and the like. Appropriate technical expertise will be needed to assess the regulations, reference standards, codes of practice (for engineers), design guidance, technical qualifications, etc. Specific disciplines include fire protection engineering (or fire safety engineering) and structural fire engineering. These persons should hold university qualifications in their discipline and preferably professional engineer or chartered engineer status in their respective disciplines as well. They should have at least 10 years of experience with the design of appropriate components (e.g., fire detection, fire suppression, smoke control, fire performance of structure, egress, smoke control, etc.). For those working on disaster risk and vulnerability mitigation, experience in investigative studies will be helpful (e.g., post-fire assessment of buildings).

An ideal candidate would have the following qualifications:

- Professional degree from a leading university in fire protection engineering
- A minimum of 25 years of experience in the area of fire protection engineering
- Track record of participation in policy discussion in relation to safe building and infrastructure
- Strong conceptual and research or analytical skills with the ability to rapidly analyze and integrate diverse information from varied sources into conclusions and actionable recommendations
- Demonstrated understanding of the influence of legal structure on building regulatory frameworks
- Demonstrated understanding of, and experience in, regulatory development for the built environment
- In-depth knowledge of and expertise on good practice building regulation and regulatory compliance mechanisms
- Background experience working on building project supervision
- Demonstrated understanding of planning, building, and fire department requirements for support of building regulatory frameworks
- Strong understanding of planning and land-use issues, with a proven track record working with municipal or local bodies
- Understanding of good practice building regulation and regulatory compliance mechanisms
- Computer literacy, including familiarity in the use of Microsoft software (Word, Excel, and PowerPoint)

Component 3 — Implementation and Capacity Building (needs will vary by program scope)

Policy Expertise — Implementation

The principal qualification for the policy expert at this level is hands-on experience in implementation and enforcement, such as building control officer (code official, verifier, certifier) and fire prevention or fire control officer. The ideal person will have had at least 10 years' experience managing a local building or fire prevention department, with responsibility for hiring, training, and assessing staff, preparing and managing budgets for implementation and enforcement, and dealing with reviews, approvals, appeals, and related legal matters. This person might be qualified as a certified planner, certified building code official, or certified fire prevention officer. Education in a related discipline would be expected.

Policy Expertise — Societal Capacity Building

The principal qualification for the policy expert at this level is hands-on experience integrating social capacity building into co-developed regulatory structure. The ideal person will have had at least 10 years of experience working with mechanisms for engaging with disadvantaged or vulnerable populations, social services, teaching, and related areas with respect to individual and social fire prevention and protection strategies. These persons should hold university qualifications in their disciplines as well as, preferably, registered, licensed, or chartered status.

Technical Expertise

The expertise at this level would ideally be related to the required technical discipline (fire). An appropriate engineering or technical qualification would be expected, as well as at least 10 years of experience, likely gained at the local (regulatory enforcement) level.

Local Knowledge and Experience

To supplement personnel with the policy and technical expertise and experience outlined above, it will be essential to identify a local counterpart in the country of the project. Local counterparts should understand the legal, regulatory, and technical environments appropriate to the project and possess experience at the appropriate level, as outlined above. This person will be essential in helping to reach the right persons from whom data and capacity assessments can be collected. They will serve as conduits for local connections, helping to address language, culture, and societal considerations.

Appendix B: Legal and Administrative

Context

A fundamental governmental responsibility is to protect the health, safety, and welfare of the general public. This responsibility is often articulated within the constitution, charter, or other foundational document that defines and enables the authorities and duties of the state. The level of government at which particular protections are provided can vary based on the type or form of government and the authority and accountability accorded the responsible entities within the government. The form of law, or legal framework, is also an important consideration with respect to enabling, enacting, promulgating, and enforcing regulations and market instruments, such as insurance. By ***form (rule) of law*** we refer to largely to common law, civil law, customary law, and their various combinations.

Why Does Understanding the Legal Basis Matter?

Inadequate or incomplete legal and administrative frameworks can undermine the effectiveness of a building regulatory framework, making it difficult to achieve the intended benefits. Assessment of the existing legislative and legal foundation for building-related laws and regulations can identify shortcomings and provide the basis for relevant technical and legal assistance. Before the framework can be assessed, the foundational information must be collected.

Since a wide range of legal and administrative frameworks are in use around the world, and the required information can exist in many government entities and at various levels of government, one needs to know where to look. In a unitary government system, this might be a small number of central government ministries or agencies (as in New Zealand, for example). In a federal system, it might be necessary to consider dozens of national, state, and local government entities (as in the United States). The baseline type and form of government will indicate where pertinent government information will be found.

Several government entities may have some type or degree of responsibility, depending on the project's overall objective (e.g., "disaster risk/vulnerability reduction" as compared to "facilitating energy efficient buildings"). For this reason, it is important to understand which entities may be responsible for the types of information required for a given project.

Table 4: Information finding

Legislated Area	Level of Government	Type of Document	Where to Look
Land use	National	Resource Management Act or equivalent	Ministry of Environment or equivalent
	National or local	Planning/Zoning Regulations or equivalent	Ministry of Environment or equivalent
Buildings	National	Building Act or equivalent	Ministry of Construction or equivalent
	Regional or local	Building Regulations (codes, standards,[89] laws)	Ministry of Construction or equivalent
	Regional or local	Building regulation orders, ordinances, etc.	Local Council or equivalent
Fire prevention	National	Fire Services Act or equivalent	Ministry of Public Safety or equivalent
	National, regional, or local	Fire Regulations (codes, laws)	National, regional, or local authority
Energy conservation /efficiency	National	National Climate Policy, Energy Policy, Resource Management Policy	Office of the PM, Ministry of Environment, Ministry of Energy, and so forth
Climate change /hazard resiliency	National	National Climate Policy, Resiliency Policy, Disaster Recovery Policy, and so forth	Office of the PM, Ministry of Environment, Ministry of Disaster Response and Recovery, and so forth
Licensing and certification of practitioners	National or local (or market, e.g., professional society)	Building Act, Planning Act, etc.; Building regulations, zoning regulations, etc.; consumer protection policy	Office of Consumer Affairs, Board of Professional Engineers, etc. (or Institution of Architects and so forth)
Licensing and certification of contractors	National or local (or market, e.g., professional society, industry association)	Building Act or equivalent, building regulations, consumer protection policy	Office of Consumer Affairs, Board of Contractor Licensing, etc. (or Association of Electricians and so forth)
Product certification	National (or market, e.g., insurance entity)	Building Act or equivalent, building regulations, reference standards; consumer protection policy	National Bureau of Standards, National Product Testing Laboratory, etc. (or Underwriters Laboratories, etc.)
Insurance	National (e.g., flood insurance) or market	Resiliency policy, disaster recovery policy, and so forth	Emergency Management Agency (or market)

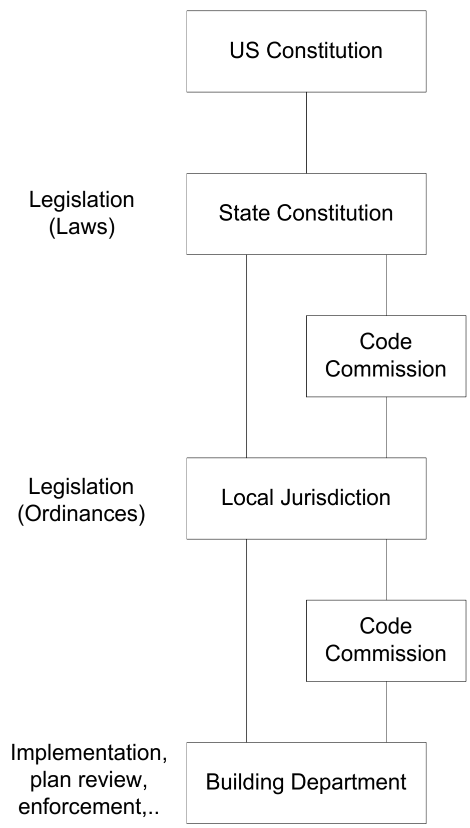
[89] In this context, it should be noted that *regulations*, *codes*, and *standards* have equivalent meaning; for example, England's Building Regulations are equivalent to New Zealand's Building Code, Scotland's Building Standards are equivalent to Japan's Building Standards Law, and so on. Terminology is a function of the country and legal system. It should also be noted that *standards*, in this regard, differ from *reference standards*, which provide details on such areas as testing, design, installation, and maintenance and are developed by standards-making organizations, such as the International Organization for Standardization (ISO) or equivalent in each country. Reference standards are specified in top-level regulations as means to demonstrate compliance.

Federation (e.g., combination of national government and regional and/or local government responsibility)

In federal system countries, all the above types of information will need to be identified at each level of government: national, regional (e.g., state, territory, or province), and local (as appropriate). In such countries, it will be important to know the regulatory hierarchy as well. For example, in the United States, buildings are regulated at the state or local level, as is planning and zoning. However, resource management and environmental regulations exist at national and state levels. As such, understanding how the hierarchy of regulations works will be important to inform decisions relative to understanding what land areas might be available to be built on, what types of assessments and permission will be needed, and so forth.

For example, consider the building regulatory hierarchy in the United States. The United States has no federal mandate around building legislation or regulation, so this becomes the purview of the states. State constitutions generally define the level at which buildings are regulated and controlled. States often establish building code commissions (or similar) to develop regulations (often adopting the International Building Code (IBC), with or without modification). States may also delegate some responsibility to local government. This is often the case for building control (enforcement). This hierarchy is illustrated below.

Figure 26: Building regulatory hierarchy in the United States



Appendix C: Development and Maintenance

Context

Having established where legislative authority over and responsibility for control of building design, construction, and use lie, the next task is to review the regulatory documents themselves, with particular focus on building fire safety provisions, to determine the specific requirements to be complied with.

In general, this assessment seeks to identify and describe the organizations responsible for developing and promulgating regulations, the particulars of the regulatory development process, the level and inclusiveness of the organizations' participation in regulatory development, and the extent to which the regulations reflect appropriate solutions in terms of the local political, social, cultural, technical and economic conditions.

For purposes of the Urban FRAME, the building fire safety regulatory framework includes land-use planning, zoning, and building and fire regulation. There can be numerous applicable regulations, and they can derive from a range of acts or other enabling legislation. For example, regulation of fire safety in buildings may be enabled by building acts or legislation, fire service acts or legislation, and environmental or resource management legislation (the latter relating particularly to wildland fire and issues of wildland-urban interface). The range of regulations enabled by these acts or legislation can include planning and zoning regulations, building regulations, fire (or fire prevention) regulations, accessibility/universal design regulations, cultural/heritage protection regulations, and the like. The components of the building fire safety regulatory framework function holistically to assure that a particular building, on a particular site, exposed to well-characterized fire hazards, can achieve minimum performance levels.

When conducting Urban FRAME assessments, note that the terminology used to describe the components in the building fire safety regulatory system may vary by country. For example, the regulatory document associated with mandating provisions for building design and performance is called Building Regulations in England, Building Standards in Scotland, Building Standards Law in Japan, and Building Code in Canada, New Zealand, the United States and several other countries. Likewise, one finds the Fire and Rescue Services Act in England, the Fire Service Law in Japan, the Police and Fire Reform (Scotland) Act in Scotland, and the Fire Code in Canada, the United States, and elsewhere. Because provisions for fire safety can be found across various legislation and regulation, the term ***building fire safety regulatory system*** is used to describe the combined building and fire focus of the Urban FRAME, and term ***building fire safety regulations*** is used to reflect specific considerations within the system to be explored.

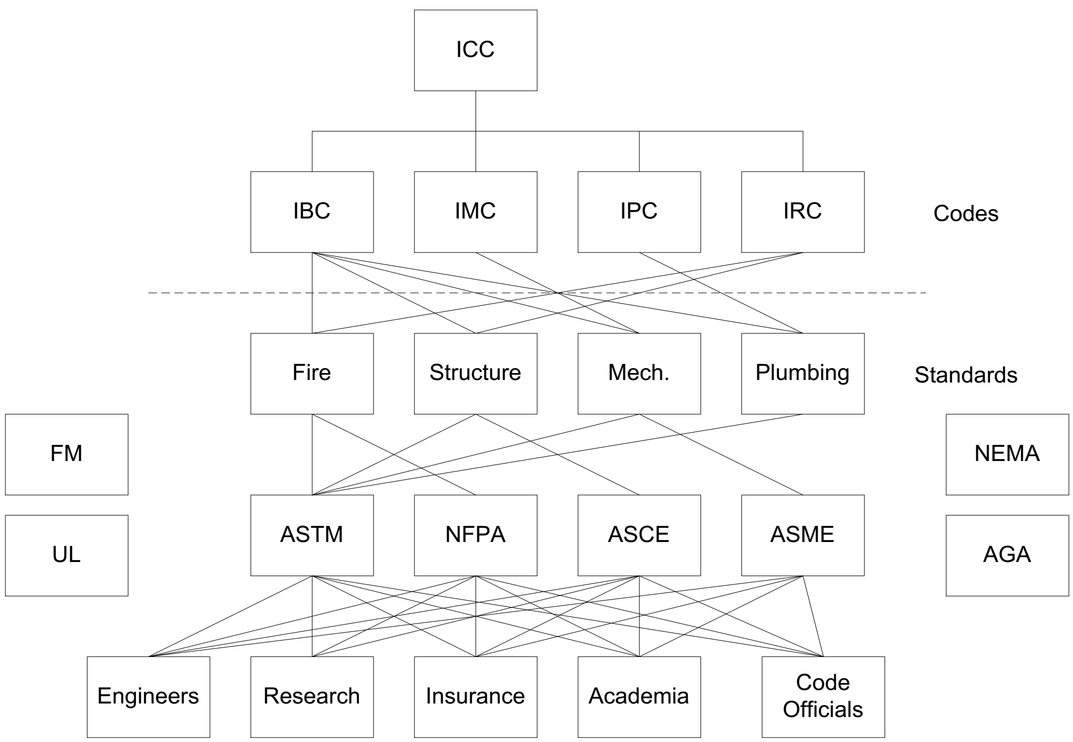
In terms of development, acts and legislation come from government at the national or the regional level, depending on the form of governance system (e.g., a single national system versus a federation of states or provinces). However, development of regulations may be undertaken by governments or the private sector. In either case, regulations will have the force of law when adopted and implemented through enabling legislation at a state, territory, provincial, or local level.

Using the term ***regulation*** for legally enforceable regulatory documents also helps differentiate these from consensus standards (or reference standards), which are developed by recognized standards development organizations (such as a country's National Bureau of Standards, the International Organization for Standardization (ISO), or similar), and design codes or codes of practice, such as the Eurocodes for Structural Design.

Consensus (reference) standards and design codes are often developed in the private sector, through a consensus process involving stakeholders across many areas, and focus on specific requirements associated with testing, design, installation, and maintenance of materials and systems. Such reference standards and design codes may be cited by reference in building regulation, making them legally enforceable, or they may be made available as voluntary guidance. Many hundreds of reference standards and design codes may underpin a comprehensive building regulatory framework.

The relationship can be seen by considering an example such as the relationships between the International Building Code (IBC) in the United States and related regulations, standards, and market entities. The IBC is a model code developed by the International Code Council (ICC), a private sector code development organization. The IBC contains the top-level regulatory provisions for buildings, which, if adopted into law at a state or local level, become the legally enforceable building code (regulation). However, the IBC is not the only applicable code that must be adopted into law. Numerous other codes (regulations) support the IBC, including the International Mechanical Code (IMC), the International Plumbing Code (IPC), the International Fire Code (IFC), and several others, each addressing specific attributes of a building's framework or features. Within each code are numerous reference standards, specifying all types of material, system, and product performance, quality, design, installation, and test and maintenance features. This is illustrated below.

Figure 27: Relationships between the International Building Code (IBC) in the United States and related regulations, standards, and market entities



The IBC alone references more than 500 standards, many of which in turn reference several others. There can be literally thousands of applicable standards within the regulatory framework. For example, requirements for materials, systems, and component performance and for design, installation, and test and maintenance associated with fire protection are largely addressed by standards set by the National Fire Protection Association (NFPA), but also by test standards such as those from the American Society of Testing and Materials (ASTM) and product certification standards such as from Underwriters Laboratories (UL) and others. Likewise, structural design provisions and basic structural material properties are largely addressed by standards of the American Society of Civil Engineers (ASCE), supported by the American Iron and Steel Institute (AISI), the American Concrete Institute (ACI), and others, which in turn are supported by test standards, such as those from the American Society of Testing and Materials (ASTM), and product certification standards, such as from Underwriters Laboratories (UL) and others.

Building and fire safety regulations may be promulgated at the national level (in a unitary government system), the state (territory, provincial) level (in a federation), or the municipal level (in either system). The provisions of the building and fire regulations establish the legally mandated design requirements, functional requirements, and construction practices.

The regulatory development process varies from country to country. In countries with a unitary government system, the building and fire regulatory development processes are often managed by a unit of the national government (e.g., Ministry of Construction, Public Works, Urban Development, and so on). In federal systems, the regulations may be developed by a government entity, a quasi-government entity, a research institution, or a private sector entity, but they are not legally enforceable until adopted via enabling legislation. The process varies by country and can reflect the form of law (i.e., civil law, common law, customary law or some combination or variation) and of the regulatory style (i.e., adversarial, elite consensual, or strong central government).

In many respects, building fire safety regulations represent the embodiment of data, political policies, public perceptions and expectations, and expert judgment about technical aspects of building performance and social evaluation of tolerable or acceptable risk. To adequately reflect the breadth of issues and perspectives, the building fire safety regulatory development process should be broadly representative of technical specialties, including expert engineers, architects, building researchers, manufacturers and suppliers of construction materials and systems and representatives of the construction and real estate industries, the building finance and insurance industries, organizations concerned with public health and safety, and building owners and occupants.

Building fire safety regulations should be periodically reviewed and updated to address shortcomings or reflect improvements based on experiences of loss to hazard events; new research and technology; new policy objectives, such as climate change adaptation or universal accessibility; changes in social norms; and affordability objectives. Critical functions of the building fire safety regulations include setting the benchmark for the minimum level of acceptable performance in terms of safety, health, and welfare of the occupants in case of fire and doing so in a way that facilitates the introduction of new knowledge and improved processes into building practices. This requires that regulations be written in clear language accessible to designers and builders and, to the extent possible, to informal sector builders. Regulations should aim to cover all prevalent construction types, providing guidance for safe construction and use of buildings.

At the end of the day, building fire safety regulations must be local instruments that address local economic, social, and technical capacity. This is particularly true for low- and middle-income countries, which require regulations appropriate to local conditions. However, for expediency, reference is sometimes made to building regulations from developed countries (e.g., the International Building Code, the Building Code of Australia, the Building Standards Law of Japan, etc.). In these cases, it is imperative to understand the extent to which such documents, if used, can be effectively adapted to meet local conditions, materials, expertise, and values and that the associated level of required regulatory infrastructure is in place.

Appendix D: Implementation and Capacity Building

Context

Once the legislative and legal foundation for building fire safety regulation is established and building fire safety regulations have been promulgated by the relevant authority having jurisdiction, the critical remaining step is implementing and managing the building fire safety regulatory regime. This component involves government, industry and owners, and community sectors and requires consideration of suitable capacity within each sector.

With respect to the government sector, building code compliance, often referred to as ***building control***, and fire prevention compliance, which may be referred to as ***fire prevention control***, are the key aspects. Building control and fire prevention are two of the most important aspects of the building fire safety regulatory system, as these are the points at which compliance is to be determined and assured. If the building control or fire prevention components are weak, it can negate the benefits of strong legal foundations and technical regulations.

Implementation and capacity building within the government sector focuses on the type, organization, efficiency, and effectiveness of the building control and fire prevention framework(s), in particular the regulatory implementation by governmental entities responsible for compliance and enforcement of building and fire regulations and other jurisdictional ordinances relating to enhancing the safety and quality of life within their jurisdictions, such as planning, zoning, building, fire, resource conservation, or accessibility ordinances. Having an adequate building control framework is critical for ensuring building quality and safety.

Of the various types of enforcement frameworks, the principal ones are solely or fundamentally governmental, solely or fundamentally private sector, or some combination, often with both a governmental option and private sector option. More broadly, building control in such frameworks may contain some of all of the following functions: planning and zoning control (e.g., siting of the building); control of technical requirements (e.g., permitting, plan review, building regulation or code compliance); control activities during construction (e.g., inspection); completion of the building (e.g., final inspection and/or commissioning); and maintenance and use (e.g., inspection and enforcement). Within governmental frameworks, these functions may range across several agencies or departments (e.g., planning, building and fire). In frameworks with private certification or building control, some or all of the functions are undertaken by private sector entities.

Other frameworks are more quality management structures, where design “self-certification” or “self-approval” is made by qualified design professionals without any significant government or private sector building control.

The adequacy of building control and fire prevention functions depends fundamentally on the number, competency, and qualifications of building control and fire prevention officers and practitioners (government, private sector, or both). Local implementation and enforcement are in many cases a critical point of failure in the pursuit of resilience.

In addition, a well-functioning building fire safety regulatory framework requires educated professionals and properly trained skilled tradespersons for the system to work well. This is part of the industry and academic sector. A focus for this area is on having an appropriate number of university educational programs for professionals, such as architecture and fire safety engineering, but also appropriate training institutions for skilled tradespersons involved in such areas as construction, installation, and maintenance of buildings and systems. In the case of fire safety engineering and system design, support or facilitation of new university programs specific to fire safety engineering may be required, as well as technician level education on system design.

In addition, these people should be trained on the regulations and supporting infrastructure (e.g., standards). As such, it is helpful to have educational curricula regarding the structure, content, and use of land-use planning, building, and fire regulation that can be used as a basis of formal education and continuing professional development.

It is also essential to socialize the benefits of the building fire safety regulatory framework via social networks outside traditional channels, especially within informal settlements and other unregulated areas, where traditional communication paths may be absent. This is an aspect of community capacity building. This may be through the social workers, medical professionals, NGOs, or others who work with inhabitants, observe conditions, and help facilitate changes. Having outreach materials about the benefits of formal regulatory frameworks and components can be very useful in this regard.

Community capacity building can be as important as regulatory capacity building, even more so in areas of informal settlements and construction, where government or municipal intervention is not currently possible at the same level as in areas subject to formal planning and construction. Informal building areas can contain a significant amount of informal construction, densely packed, with inadequate water supplies for firefighting and inadequate access for firefighting vehicles. As such, it is important to work with the local community to co-develop means to increase community capacity for fire risk reduction and mitigation and to be better prepared when fires occur.

Social services from government, activities by NGOs, and local social entrepreneurs can be helpful in establishing and promoting fire risk reduction campaigns, fire safety and evacuation training, and distribution of fire safety equipment. Local communities can work together to enhance community fire alerting, evacuation planning, and firefighting capacity, focusing on appropriate communication methods and technologies to assist. Fire safety management plans over which communities feel ownership, and which are supported by government, NGOs, and other stakeholders, can be robust, cost-effective, and sustainable. Local knowledge, expertise, and social networks can be leveraged through societal capacity building, wherein community members' responsibilities can be established, and technical and organizational capacities can be strengthened.

Appendix E: Building Fire Safety Features and Strategies

With respect to specific building fire safety and protection provisions that might be expected within either the building regulations or codes, fire prevention regulations or codes, or both, a wide variety of fire protection systems and features can be implemented into buildings to reduce fire risk. The purpose of these fire protection systems and features is to (a) prevent fire, (b) manage fire, or (c) manage people, contents, etc., exposed to fire. These fundamental tenets of fire safety design are well reflected in the Fire Safety Concepts Tree (FSCT) of the U.S. National Fire Protection Association (NFPA), which provides a useful decision structure to help identify options for effectively preventing or managing fire impacts.[90]

Recently, the International Fire Safety Standards (IFSS) Coalition, a group of professional, not-for-profit organizations that largely operate in the fire safety space, came together to research, develop, publicize, and implement a set of common principles for fire safety in the construction and real estate sectors.[91] Their work, the International Fire Safety Standards: Common Principles (IFSS CP), are meant to address fire safety aspects of engineering design, construction, occupation, and ongoing management, relevant to all real estate classes and all regions and nations, regardless of political, economic, social, technological, legal, or environmental differences. As reflected in the IFSS CP document, the Common Principles are:[92]

- *Prevention*: Safeguarding against the outbreak of fire and/or limiting its effects.
- *Detection and Communication*: Investigating and discovering fire, followed by informing occupants and the fire service.
- *Occupant Protection*: Facilitating occupant avoidance of and escape from the effects of fire.
- *Containment*: Limiting fire and all of its consequences to as small an area as possible.
- *Extinguishment*: Suppressing fire and protecting the surrounding environment.

The fire protection systems in buildings are often discussed as being either ***passive***, meaning they generally do not require electrical power or water to perform their function (e.g., fire-rated construction, fire doors, etc.), or ***active***, meaning they require some type of activation, as well as generally requiring electrical power (e.g., smoke alarm, fire alarm and communication system, mechanical smoke exhaust systems, etc.). Fire suppression systems, such as fire sprinkler systems, are considered active because they require a device to activate them (e.g., thermal link in a sprinkler head or fire detector of some type), and they may require fire pumps, which need a power source to operate. To supplement passive and active fire protection systems, systems to support manual fire protection intervention are generally included in the fire regulatory system. Within buildings, this includes internal hydrant (standpipe) systems, hose reels, fire extinguishers, and related equipment that requires operation by a person, whether an occupant or a firefighter.

The extent to which fire safety features are included in regulations is often driven by the building's occupancy or use classifications (e.g., places of public assembly, domestic or residential, places of business, mercantile, industrial, and storage), which are in turn informed by the level of hazard present and the risk to occupants. The types of fire safety systems and features that may be part of building fire safety regulations include the following, grouped by type of fire safety or protection afforded.

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[90] NFPA 550 (2017), *Guide to the Fire Safety Concepts Tree* (Quincy, MA: NFPA).
[91] See https://ifss-coalition.org/ (last accessed 5 October 2020).
[92] International Fire Safety Standards: Common Principles (1st edition). International Fire Safety Standards Coalition, 2020 (ISBN 978 1 78321 384 9).The IFSS CP document is available for download at https://www.rics.org/globalassets/rics-website/media/news/news--opinion/fire-safety/ifss-cp-1st-edition.pdf (last accessed 5 October 2020).

- Fire prevention
    - Controls on electrical ignition hazards
    - Controls on heating appliances
    - Controls on fuel sources (e.g., natural gas, propane, fuel oil)
    - Controls on storage and/or amounts of hazardous/combustible/flammable material
- Means to facilitate safe escape from inside buildings
    - Passive systems
        - Egress system components (e.g., protected corridors, protected stairs, etc.)
    - Active systems
        - Smoke alarms (self-contained smoke detection and alerting for housing units)
        - Smoke detectors (for public, commercial, industrial buildings)
        - Heat detectors
        - Fire notification appliances (audible alarms and visual alarms)
        - Voice alarm communication systems
        - Manual fire alarm points (pull stations)
        - Fire alarm controls panels (integrating the above in public, commercial, industrial buildings)
- Means to manage fire spread
    - Passive systems
        - Structural fire resistance requirements (primary and secondary structure)
        - Fire resistance of interior walls, including doors, vents, and other openings in walls
        - Fire spread limitations on interior walls, ceilings, and floors (to limit spread of fire and smoke)
        - Fire resistance and fire spread requirements for exterior walls (façade systems, wall systems, etc.)
    - Active systems
        - Smoke management
            - Smoke control systems
            - Smoke exhaust systems
            - Smoke venting systems
        - Suppression systems
            - Occupant hose reels (for occupant firefighting)
            - Fire extinguishers (handheld, for occupant use)
            - Firefighters standpipe (hydrant) system (for firefighter use)
            - Fire sprinkler systems
            - Firefighting water supply (to building, in building (e.g., tanks))
            - Connections for firefighter apparatus
            - Special suppression or extinguishing systems (e.g., water mist, CO2, etc.)
            - Fire department or brigade access requirements (for apparatus, reaching the building, etc.)

The relationship between fire safety systems and features that are part of building fire safety regulations (within the building regulations, fire regulations, or both) and operational firefighting capacity include:

- Means to notify the fire service (e.g., automatic by building fire protection systems, manually via phone or other)
- Fire service access to the building (may be via planning regulation and/or R2R diagnostic)
- Fire service resources (e.g., personnel, apparatus, training, etc.)

There are many potential starting points for assessing the components within the fire regulatory system of a country, including NFPA 550 and the IFSS CP, both of which have been developed to be universally applicable throughout the world, regardless of the existing codes, standards, and guidance already in place. The NFPA 550 document is helpful in developing strategies for fire-safe design. The IFSS CP provides more details on means to achieve fire safety strategies through the five stages of a building's life:

1. Design
2. Construction
3. Use
4. Alteration
5. Demolition

Details include recommended documentation, information requirements, fire safety strategies and measures, and accountability and verification. The IFSS CP also provides a framework that can be useful for analyzing fire regulatory systems for the extent to which they fulfill the common principles.

Appendix F: Fire Safety Environment and Regulatory Systems in Developing Countries: A Case Study on South Africa

The following case study was developed by Professor Richard Walls from the Fire Engineering Research Unit of Stellenbosch University (FireSUN), South Africa.

A country's fire safety regulatory framework and environment will significantly affect how designs are carried out, as well as how authorities implement/control fire safety aspects. The fire safety environment in South Africa (SA) illustrates several of the factors that may need to be considered when assessing a country's fire safety, especially for low- and middle-income communities. Details regarding the fire safety legal framework are provided, and generalizations relating to consulting engineers, code development, product testing, and the regulatory environment are addressed.

Consulting engineering environment

In relation to many developing nations, South Africa has a relatively strong technical engineering capacity, especially when compared to most countries in Africa. However, fire safety competency has often lagged behind other technical fields, for a variety of reasons. Formal university qualifications for professional engineers only began to be developed in recent years, with the first formalized postgraduate qualifications being offered in 2019.[93] A framework and certification system specifically for professional consulting fire engineers is being implemented under the Engineering Council of South Africa (ECSA), but this still requires several years to have an impact on the industry.

Historically, professional engineers carrying out rational designs were mechanical, civil, or electrical engineers who then also became involved in projects' fire safety aspects (a similar pattern occurs in many other countries). Very few consultants who consider themselves fire engineers have formal university fire engineering qualifications (e.g., in fire dynamics, suppression systems, evacuation, etc.), and they have primarily learnt through on-the-job training, possibly combined with a limited number of short courses. Many fire engineers are former fire chiefs, who typically have excellent knowledge regarding code application and can produce good deemed-to-satisfy solutions but often may lack the mathematical basis to carry out engineered designs.

All the aforementioned factors mean that the quality of rational designs produced by fire engineers varies significantly, with many being substandard or lacking fundamental understanding of fire behavior. Unfortunately, this results in rational designs that regulatory bodies view primarily as a way of flouting requirements (to produce cheaper buildings for clients rather than enhance safety), and hence authorities are wary of approving engineered solutions. This limits innovation and the application of performance-based solutions to address problems, and instead standards are rigidly (although often incorrectly) enforced. If performance-based solutions are developed, they are typically done for high-end commercial, residential, and industrial projects, while low- and middle-income projects are rarely considered.

[93] R.S. Walls, A. Cicione, B. Messerschmidt, and K. Almand (2019), "Africa: The Next Frontier for Fire Safety Engineering?," in *15th Int. Conf. Exhib. Fire Sci. Eng.*, London: pp. 819–29.

Codes, standards, and fire safety authorities

South Africa (SA) has two broad classes of occupancies: formal occupancies and informal occupancies. Codes and standards are typically applied to the former, but authorities apply almost no building control regulations to the latter. This effectively leads to a dual system, where, for example, a crèche built by an NGO in the middle of an informal settlement has to strictly follow all building code regulations, but all the informal homes surrounding it have no requirements imposed on them.

SA's National Building Regulations (NBR) Act is primarily implemented through the SANS 10400 series of standards.[94] The NBR Act (Act 103 of 1977),[95] states that the aim of the Act, in terms of fire safety, is:

> *. . . to provide for the requirements with which buildings shall comply in so far as precautionary measures against fires or other emergencies are concerned, including the resistance of buildings against the outbreak and spreading of fires, the protection of the occupants or users of buildings or other persons against fires, the aids or other installations to be in buildings for the combating or prevention of fires and for the vacating of such buildings in cases of fires or other emergencies.*

These guidelines are then given a qualitative description (referred to as functional regulation), in terms of fire safety, as follows in SANS 10400-T:[96]

> *Any building shall be so designed, constructed and equipped that in case of fire:*
> *a) the protection of occupants or users, including persons with disabilities, therein is ensured and that provision is made for the safe evacuation of such occupants or users;*
> *b) the spread and intensity of such fire within such building and the spread of fire to any other building will be minimized;*
> *c) sufficient stability will be retained to ensure that such building will not endanger any other building: Provided that in the case of any multi-storey building no major failure of the structural system shall occur;*
> *d) the generation and spread of smoke will be minimized or controlled to the greatest extent reasonably practicable; and*
> *e) adequate means of access, and equipment for detecting, fighting, controlling and extinguishing such fire, is provided.*

Hence, SA codes provide a performance-based framework through which designs "can be established to reflect societal expectations in a developing country, in a manner which supports sustainable development objectives."[97] The SANS 10400 codes provide a qualitative (as above) and quantitative description of the attributes that structures should adhere to. Deemed-to-satisfy (i.e., quantitative) rules are provided in multiple documents (e.g., SANS 10400-T for fire safety), giving very specific requirements that should be followed to produce code compliant projects.

Since SA's building regulations are based on performance-based requirements, through qualitative descriptions of performance, it would be thought that suitable fire safety solutions could be developed for low- and middle-income communities, along with all other groups, that could provide a standard of safety commensurate with their level of income and resources. However, due to the lack of technical expertise in the country, and resistance from approval authorities (based on the issues noted above), this has rarely been implemented. Rather, the dual system of either applying all deemed-to-satisfy regulations, or applying no regulations at all, continues. This is exacerbated by the fact that when authorities are determining if a person is competent to carry out rational designs, SANS 10400 "falls short of establishing definitive minimum criteria for establishing the abilities of competent persons."[98] Furthermore, fire safety regulations are developed based on standardized structural configurations and extant products. Buildings with complex geometries (e.g., a multistory atria), unusual occupancies, and new products may not be covered within existing codes. Hence, simply applying deemed-to-satisfy regulations to all

[94] SABS, SANS 10400 (2011), "The Application of the National Building Regulations," SABS, Pretoria.
[95] Republic of South Africa (1977), National Building Regulations and Building Standards Act 103, Gov. Gaz. 145.
[96] SABS, SANS 10400-T (2020), "The Application of the National Building Regulations Part T: Fire Protection, South African Bureau of Standards," SABS, Pretoria.
[97] R. Watermeyer and R. Milford (2003), "The Use of Performance Based Building Codes to Attain Sustainable Housing Objectives: The South African Approach," in *Glob. Policy Summit Role Performance-Based Build. Regul. Addressing Soc. Expect. Int. Policy, Local Needs*, IRCC / NRC: pp. 1–14.
[98] R. Watermeyer (2014), "An Overview of the Current National Building Regulations and Their Impact on Engineering Practice," *Civ. Eng.* (March): 41–44.

buildings may actually lead in some cases to increased fire risk and unsuitable solutions.

Along with fire safety frameworks, specific guidelines provided for a broad range of construction systems must be considered. Multiple codes are needed to provide very specific details regarding aspects such as sprinkler installation, material flammability, and structural resistance to fire. In developing countries, it is often expedient to adopt international codes rather than to develop them locally, due to a lack of financial and technical resources. However, this can lead to situations where codes from multiple countries with different levels of safety or requirements provide contradictory, or at least confusing, recommendations. Table 5 lists fire-related codes and the international documents they are based on, illustrating how SA has used international standards. Work on a single project may require guidelines from 5 to 10 different international organizations, at times resulting in inconsistent levels of fire safety. Furthermore, use of multiple code sources allows engineers to "cherry-pick" the guidelines they will implement, and often they simply select those that provide the cheapest solution, rather than a suitable level of safety.

Table 5: Examples of South African codes in relation to fire safety and the source of the information contained in them

South African Code	Code Based On
Building code fire regulations	Locally produced, but based upon British and other recommendations
Fire performance of external cladding	British standard BS8414-1
Fire performance of unprotected small cables	Eurocode EN 50200
Steel in fire	Canadian code CSA-S16
Water spray fixed sprinklers	NFPA 15
Reaction to fire tests for products	International standard ISO 1716
Fire testing of roof coverings	American Standard ASTM E 108

A final important consideration regarding fire safety in a country is the availability of test laboratories and the costs associated with certifying products. SA has two main fire laboratories testing construction products, the second of which opened within the last two years. This leads to delays in product testing, and in many instances products are not tested at all, but may be sold as if they had been certified (due to either suppliers' negligence or their ignorance). Many of SA's test standards, especially for structural and cladding systems, differ from those in Europe and the United States, where limits are placed on the amount of international products and test certificates that can be used. Hence, a product that has been certified for the European market often must undergo additional tests before it can be sold locally. A separate issue is that solutions developed for low- and middle-income communities often involve structural configurations proposed by engineers or architects that require testing, but the cost and time requirements associated with the certification process may be prohibitive, making the solution unfeasible and causing extant solutions to be used instead.

Case study conclusions

The discussion above provides a brief overview of important aspects of fire safety in developing countries, with a focus on South Africa. Even when a regulatory system exists that allows for innovative design and performance-based solutions, such solutions may not be developed or approved due to a lack of technical expertise, from both consulting engineers and approval authorities. Such issues require extensive investments in education, development, and regulation at all levels, and typically many years are required before significant progress can be made. The presence of codes and standards for regulating fire safety is important. However, developing countries adopting a variety of international codes may find that although they lead to varying levels of fire safety, but they may also cause confusion or challenges in the design process.

Fire safety in low- and middle-income communities thus remains an ongoing concern. But as a final comment, however negative the discussions above may sound concerning the contemporary challenges facing South Africa, many advancements have been made, and in some municipalities, along with high-end or industrial projects, great strides have been made toward improving fire safety.

The Urban Fire Regulatory Assessment and Mitigation Evaluation (Urban FRAME) diagnostic is designed to support government officials and project managers, including World Bank Task Team Leaders, in assessing building fire safety regulatory systems, identifying critical gaps and opportunities for building and urban fire risk reduction projects, and investment planning.

As part of the Global Facility for Disaster Risk Reduction (GFDRR), the Building Regulation for Resilience Program develops and promotes activities to increase regulatory capacity to promote a healthier, safer, and more sustainable built environment. By leveraging good practice in building regulation as part of a strategy to reduce both chronic and disaster risk, it sets low- and middle-income countries on the path to effective reform and long-term resilience. For more information, visit: www.gfdrr.org/en/building-regulation-for-resilience

The GFDRR is a global partnership that helps developing countries better understand and reduce their vulnerabilities to natural hazards and adapt to climate change. Working with over 400 local, national, regional, and international partners, GFDRR provides grant financing, technical assistance, training, and knowledge sharing activities to mainstream disaster and climate risk management in policy and strategy. Managed by the World Bank, GFDRR is supported by 34 countries and 9 international organizations.

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