TECTONIC SHIFT

RIFT2018

Regional Seismic Risk and Resilience Workshop

NAIROBI, KENYA

SEPTEMBER 19-21

REPORT

Building Disaster Resilience in Sub-Saharan Africa

An initiative of the African, Caribbean and Pacific Group of States funded by the European Union

GFDRR
Global Facility for Disaster Reduction and Recovery

WORLD BANK GROUP

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CONTENTS

ACRONYMS & ABBREVIATIONS

ADRF .... Africa Disaster Risk Financing Initiative
AIS .... Earthquake Engineering Association (Colombia)
ATC .... Applied Technology Council
BRCA .... Building Regulatory Capacity Assessment
BRR .... Building Regulations for Resilience Program
BS .... British Standard
BSJ .... Bureau of Standards Jamaica
BRCA .... Building Regulatory Capacity Assessment
CAPRA .... Probabilistic Risk Assessment Platform
CAT-DDO .... Catastrophe Deferred Drawdown Option
CIMOC .... Research Center for Materials and Structures (Colombia)
COP .... Challenges and Opportunities Plan
Cubic .... Caribbean Unified Building Code
DRR .... Disaster Reduction and Recovery
DRM .... Disaster Risk Management
EARS .... East African Rift System
ECLAC .... Economic Commission for Latin America and the Caribbean
EERI .... Earthquake Engineering Research Institute (Colombia)
ERN .... Evaluación de Riesgos Naturales
ESARSWG .... Eastern and Southern Africa Regional Seismological Working Group
EUCENTRE .... European Centre for Training and Research in Earthquake Engineering
EUROCODE .... European building Code
GEM .... Global Earthquake Model
GFDRR .... Global Facility for Disaster Reduction and Recovery
GDP .... Gross Domestic Product
GIS .... Geographic Information System
GSURR.............................. Global Practice Urban, Rural and Resilience
ICE .... Institution of Civil Engineers
IUSS .... Institute for Advanced Study (Italy)
KEPSA .... Kenya Private Sector Alliance
KRCS .... Kenya Red Cross Society
NEHRP .... U.S. National Earthquake Hazard Reduction Program
RAP................................... Relocation Action Plan
RED................................... Risk Engineering + Development
UNISDR............................ United Nations Office for Disaster Risk Reduction

ACKNOWLEDGMENTS

This summary report was produced by the World Bank's Africa Disaster Risk Management (DRM) Team and the Global Facility for Disaster Reduction and Recovery (GFDRR). The report was developed by Theresa Maria Abrassart (Consultant, BRR-GFDRR), Ana Campos Garcia (Senior DRM Specialist, GFDRR), Thomas Moullier (Senior Urban Specialist, GSURR), James (Jay) Newman (DRM Specialist, GFDRR), Dr. Nicolas Pondard (DRM Specialist, GFDRR), and Judy Maureen Waturi (Consultant, GSURR). Nicholas Paul (Consultant, GFDRR) provided editing services.

This workshop and report are financed by the European Union (EU)–funded Africa Disaster Risk Financing Initiative (ADRF), managed by GFDRR. The ADRF is part of the larger EU–Africa, Caribbean, and Pacific (ACP) cooperation program, "Building Disaster Resilience in Sub-Saharan Africa," which aims at strengthening the resilience of Sub-Saharan regions, countries, and communities against the impacts of natural disasters, including the potential impacts of climate change, to reduce poverty and promote sustainable development.

The report greatly benefited from the information, support, and feedback provided by the Government of Kenya, specifically the Executive Office of the President, and the Ministry of Transport, Infrastructure, Housing, Urban Development, and Public Works. We thank the speakers, participating officials, and project task teams for their presentations, active involvement, and knowledge sharing. The report was designed by Carlos Plaza Design Studio.

The team gratefully acknowledges the peer review, feedback, and input from Dr. Ettore Faga (COO of RED), Luis Eduardo Yamin Lacouture (Associate Professor of the Department of Civil Engineering and Environment, University of Los Andes) and Emma Katrine Philips (Senior DRM Specialist, GFDRR).

EXECUTIVE SUMMARY

CONTEXT

Disasters associated with seismic events represent a significant development challenge in achieving the dual goals of ending extreme poverty and promoting shared prosperity across Sub-Saharan Eastern Africa. The East African Rift System (EARS) is the largest continent-scale, seismic rift system recorded on Earth today. Approximately 6,000 kilometers in length, this system extends from Djibouti to western Mozambique, generating volcanism and earthquakes and fracturing the Earth's crust. The spreading rate of the EARS is about 7 mm/year (Fernandes et al, 2004). Despite this slow rate of divergence, the East African Rift Valley and its seaward extension, the Kenya Rift Valley, are characterized by frequent seismicity with large and shallow earthquakes occurring occasionally. The EARS covers an area of approximately 5.5 million square kilometers and is home to more than 120 million people (World Bank 2017); this represents a major challenge, particularly due to the low awareness of seismic risk in the region.

With rapid urbanization and population growth in the region, the impact of future events is likely to be more severe. While there have been no major earthquakes in urban areas in the region in recent years, conditions endemic to the region mean that even medium-scale events could be particularly devastating. For example, building quality in the Great Rift Valley Region is often quite poor, as informal housing and non-engineered buildings predominate. The vulnerable infrastructure puts a great many people at great risk.

More than 30 million urban poor live in the Rift Valley, and the number could increase to 60 million by 2050. These communities are the most vulnerable to shocks and disruptions to their lives. In 1989, a 6.2-magnitude earthquake that struck Malawi killed 10 people and caused US$28 million in economic losses (World Bank/GFDRR, forthcoming). The same event today could kill as many 1,500 people and cause up to US$250 million in losses.

GOALS OF THE WORKSHOP

In September 2018, representatives from the six East African Rift countries, together with technical experts from development institutions and academia, convened in Nairobi, Kenya, to assess the risks and enable action to strengthen institutional or policy frameworks for seismic risk management and to build the capacity of selected national and local governments in Sub-Saharan Eastern Africa in the East African Rift Valley.

THE WORKSHOP WAS DESIGNED TO ADDRESS THREE QUESTIONS:

WHAT IS THE LEVEL OF RISK IN THE PARTICIPATING COUNTRIES?

WHAT ARE THE OPTIONS FOR ACTION AND INVESTMENT?

WHAT TECHNICAL MEASURES ARE REQUIRED FOR IMPLEMENTATION, AND WHO CAN BEST ASSIST WITH THIS?

IT WAS ALSO STRUCTURED AROUND THREE KEY TOPICS:

TOPIC 1
SEISMIC RISK IDENTIFICATION

During this session, speakers addressed the importance of evaluating the severity and frequency of natural events (hazard) as a first step to any risk assessment and a key milestone for the design of appropriate building codes, so that damage to properties and casualties are minimized during large earthquakes. Better assessment of the current exposure and vulnerability of the East African population and infrastructure is also essential to make better-informed risk management decisions.

TOPIC 2
RISK REDUCTION IN THE BUILT ENVIRONMENT

This session explored the importance of building and land use regulation in reducing vulnerability to seismic events. Speakers took a holistic look at building regulatory systems and their critical components: legislative and institutional aspects, building code development and enforcement, and compliance strategies. The session focused on how regulatory implementation and compliance mechanisms can be designed and executed by governments working with key stakeholders.

TOPIC 3
RESILIENT INFRASTRUCTURE

Speakers set out the main infrastructure systems and their critical facilities and components; identified their seismic vulnerability and their expected behavior during earthquakes; explored common mitigation options; and identified requirements for risk assessment and mitigation studies.

Each session was facilitated by representatives from the World Bank and included inputs from academic or technical experts with experience in similarly affected regions. The event concluded with presentations from each country's participant team of the Challenges and Opportunities Plan (COP) they had developed during the course of the workshop.

PARTICIPANTS' PROFILE AND CHALLENGES FACED

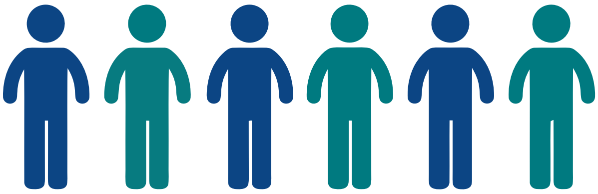
Participants included representatives from Rift Valley countries: Ethiopia, Kenya, Malawi, Mozambique, Tanzania, and Uganda. Among them were

- seismologists dealing with seismic risks zonation;
- earthquake engineers dealing with building codes;
- senior officials from the Ministry of Urban Development and Housing;
- disaster risk managers, specifically dealing with disaster risk reduction; and
- city officials managing building licenses and permits.

The workshop also brought together international experts and practitioners on seismic risk management, including from Colombia, India, and Jamaica, as well as organizations such as Africa Array, Risk Engineering + Development (RED), and Bristol University, to share experiences and lessons learned in their own countries.

Source: Mwangi Charles.

FIGURE 1: RIFT2018 Participant Survey Results



70%

of participants reported that there was a seismic monitoring system in their country, but accessing and understanding its usage was unclear to many.

65%

of participants reported that there was a seismic risk zoning map of their country. However, there was confusion and lack of clarity regarding its accuracy, legal status, and effectiveness.

69%

of participants reported that their countries communicate risk using media, technical experts, and community meetings. However, 23 percent reported that communication of risk to residents was highly ineffective.

95%

of participants reported that their countries had laws that enable the regulation of the built environment and appointment of professionals. Most reported, however, that these laws were out of date and that coordination, implementation, and enforcement needed to be improved.

100%

of participants reported that resilience was partially integrated into the design, construction, maintenance, and operation of infrastructure. Most reported constraints, however, including insufficient hazard and risk mapping, inadequate technical standards, codes, and regulation, and poor maintenance, resulting in dilapidated infrastructure.

KEY TAKEAWAYS

THE EARS IS THE MOST SEISMICALLY ACTIVE REGION IN AFRICA

and experienced at least seven events of magnitude-6.0 to 7.5 in the 20th century, causing significant building collapse, infrastructure damage, and casualties. Recent events occurred in relatively thinly populated areas, hence their relatively low impact compared to earthquakes in other regions. However, rapidly accelerating urbanization is increasing the likely impact of future seismic disasters in the region. The EARS is also the least-monitored seismic region in the world, exacerbating the uncertainty underlying this risk and reducing the likelihood of action to address it.

BUILDING QUALITY IN THE GREAT RIFT VALLEY REGION IS OFTEN POOR,

as informal housing and non-engineered buildings predominate. The vulnerability of informal housing and aging infrastructure puts a great many people at great risk. In addition, rapid urbanization—driven in part by the impact of climate change and the effects of fragility, conflict, and violence—is increasing the exposure of people and assets to seismic hazards. There are more than 30 million urban poor who live in the Rift Valley, and the number could increase to 60 million by 2050 (World Bank 2017). When an earthquake does occur, these communities are the most vulnerable to shocks and disruptions to their lives.

COUNTRIES MUST PURSUE POLICY AND INVESTMENT MEASURES TO BETTER MANAGE THEIR RISK.

Practical efforts—including policy options like national seismic risk zonation and building regulation and measures like enhanced designs for resilient infrastructure and financial protection—will be more critical than ever in saving lives, protecting livelihoods, and improving the living conditions of people whose lives are affected by disaster. Since attending the Seismic Risk and Resilience Technical Deep Dive in Japan, 2018, Kenya and Malawi have started working on enhancing their building regulations for resilience, while simultaneously pursuing innovative financial protection strategies.

FIGURE 2: Key Takeaways from RIFT2018

CHALLENGES & OPPORTUNITIES FOR ACTION

GOALS

- Increase monitoring capacity
- Achieve risk identification and public awareness
- Create and Operationalize regulatory framework
- Achieve quantifiable improvement in building stock
- Improve resilience of critical infrastructure

BARRIERS

- Low awareness and competing priorities
- Coordination
- Financing
- Incentives at local and national levels

ACTIONS

- Consider sequencing and public policy options
- Achieve recognized national hazard zonation map (starting point)
- Put a first code in place, and innovate and iterate
- Engage private sector, bot how? (e.g., construction, materials)
- Create posivility / engagement (assets), not just enforcement
- Use regional / international platforms for technical detail / good practices
- Build Capacity / Training / Curriculum (e.g., engineering)

Source: Authors.

FIGURE 3: Options for Investing in Seismic Resilience

DEVELOPMENT SUPPORT FOR SEISMIC RESILIENCE

SEISMIC RISK IDENTIFICATION
- National Hazard Mapping (Macro-zonation) to Microzonation
- Platforms / tools for exposure and vulnerability data

MONITORING, PREPAREDNESS, AND RESPONSE
- Institutional strengthening
- Preparedness drills
- Accurate and timely early warning systems

BUILDING REGULATION AND RETROFITTING
- Assess and Strengthen building regulation framework
- Construction works and targeted retrofitting
- Mainstream seismic resilience across sectors

RESILIENT INFRASTRUCTURE
- Design Standards
- Asset Management & BCP
- Risk-Informed Financing/PPP

RISK FINANCING AND INSURANCE
- Support Gov's to understand/manage contingent liability
- Insurance Market Development
- Risk Pooling and Transfer (e.g., CCRIF, PCRAFI, CAT Bonds)

CAPACITY DEVELOPMENT
- Training on Seismology and Seismic Engineering

Source: Authors.

OPENING AND WELCOME

Source: Mwangi Charles.

MR. FELIPE JARAMILLO

World Bank Country Director for Eritrea, Kenya, Rwanda, and Uganda

Together, Ethiopia, Kenya, Malawi, Mozambique, Tanzania, and Uganda are designing, implementing, and delivering critical urban development and resilience investments worth over US$3 billion with the support of the World Bank. This is in addition to the work countries are taking on on their own, and with technical and financial support from many other development partners.

This workshop brings participants together to

- determine the challenges and obstacles facing both countries and investments;
- draw lessons from the global experience of strengthening seismic resilience;
- share knowledge with the other government officials facing similar challenges;
- make lasting connections among participants, experts, and practitioners; and,
- develop solutions that will contribute to strengthening the seismic resilience of the respective countries.

Globally, earthquakes push about 4 million people into extreme poverty every year (Hallegatte et al. 2017). Ongoing urbanization without adequate territorial planning in Sub-Saharan Eastern Africa has led to a higher concentration of population and assets in hazard-prone areas. This increases exposure and vulnerability to seismic and other hazard events.

The urban population in the Great Rift Valley region is expected to double by 2050, by which time 70 percent of people will be living in cities (World Bank 2017). Almost 74.5 million additional urban dwellers will stress urban systems, with increasing demand for housing, infrastructure, services, and jobs in the Great Rift Valley countries.

Currently, nearly 60 percent of the urban population in these countries live in unsafe settlements that emerged informally (World Bank 2017). These are often located in hazard-prone areas, with limited access to basic services.

In addition to poorly regulated urbanization processes, high sustained levels of urban poverty increase seismic vulnerability in the cities of the region. While some countries have reduced levels of urban poverty, they still face important challenges in improving living conditions and reducing seismic and other risk for the 30 million urban poor in the region.

According to the INFORM Index, over 200,000 people in the RIFT2018 countries are expected to be exposed to an earthquake each year, and a large earthquake in the Rift Valley could cause catastrophic losses. In September 2016, Tanzania faced a magnitude-5.7 earthquake with unexpected damage and disruption, particularly to informal housing and non-engineered buildings.

The EU, which has supported our work on disaster resilience in Africa through the Africa Disaster Risk Financing Initiative (ADRF), understands the risks that earthquakes can pose to people and the economy. For example, in 2009, 2012, and 2016, Italy was hit by damaging earthquakes that took many lives, hurt the economy, and threatened irreplaceable cultural heritage. The experience in Europe and many countries around the world shows the importance of ensuring resilience in development.

The EU has provided substantial support for disaster risk management and resilience in Sub-Saharan Africa. In Kenya, for example, the EU helped the completion of a National Disaster Risk Finance Strategy, which informed policy actions supported by a US$200 million Disaster Risk Management Catastrophe Deferred Drawdown Option (DRM CAT-DDO) that has been supported with World Bank financing. This critical strategy is enhancing coordination for Kenya's key risk financing initiatives, including the Kenya Livestock Insurance Program and the Hunger Safety Net Program. Kenya was also able to conduct a South-South Exchange with Colombia and engage the Kenya Private Sector Alliance (KEPSA), the National Government of Kenya, and the Kenya Red Cross Society (KRCS) for enhancing DRM.

Every country at the workshop has taken concrete action to enhance its management of disaster risk:

- In Ethiopia, the government has worked with the World Bank and GFDRR to develop the Addis Ababa City Strength Strategy and a series of projects and technical assistance to enhance urban analytics, development, and investments.
- In Malawi, the government has chosen a Cat-DDO with the World Bank, which allows it to access needed funds in case of disaster. The country is also pursuing flood and drought recovery and resilience.
- In Mozambique, the government has worked to recover from various flooding events, including the 2015 floods. The World Bank has supported this recovery with a US$40 million project and is helping the government develop its next large-scale initiative to strengthen capacity to prepare for and respond to disasters and increase the resilience of key public infrastructure in risk-prone areas.
- In Tanzania, the World Bank is helping improve urban services and institutional capacity across 29 cities and towns and to facilitate emergency response capacity through the Tanzania Urban Resilience Program.
- In Uganda, the World Bank is supporting efforts to enhance urban development and resilience through mobility, economic productivity, and more resilient infrastructure.

We are eager to see your results in sharing good practice and experience in understanding, communicating, and applying seismic risk information to reduce the human and economic losses.

OPENING AND WELCOME

Source: Mwangi Charles.

MR. FRANCIS MURAYA

Senior Economic Advisor, Cabinet Affairs, Executive Office of the President, Government of Kenya

Kenya faces a wide range of natural hazards, including seismic risk; the EARS traverses the country, bisecting it into eastern and western regions. Historical records show that earthquakes of magnitude-6.0 and greater have occurred in Kenya, the worst being the January 6, 1928, Subukia earthquake at magnitude-7.1, with an aftershock of magnitude-6.2 four days later.

Should a similar quake occur today, with current building typologies and population densities, the damage would be devastating. Many buildings—constructed without earthquakes in mind—would not withstand the impact. Regulations governing construction of buildings in relation to possible earthquakes date back to the 1973 Code of Practice for the Design and Construction of Buildings. The code proposes simple, uniform, and compact rectangular configurations and discourages buildings of asymmetrical design, since such structures may vibrate in complicated ways.

Kenya's preparedness for disasters has also been challenged by insufficient capacity—reactive rather than proactive. The country remains ill-prepared to handle an earthquake, and there is a lack of public awareness on what to do during such an event. To improve preparedness, Kenya needs to integrate disaster into its business model. The recently approved National Disaster Management Policy recognizes the importance of investing in prevention, thus reducing vulnerability and promoting resilience.

The policy provides for the establishment, streamlining, and strengthening of DRM institutions and the coordination of frameworks, partnerships, and regulations. DRM encompasses the full continuum from prevention, preparedness, relief, and rehabilitation, back to mitigation and prevention of future disasters. Building the resilience of vulnerable communities to hazards entails a radical shift from short-term relief responses to sustainable development and continual risk reduction and preparedness.

This policy, if implemented, will go a long way to preserve life and minimize suffering by providing sufficient and timely early warning information on potential hazards that may result in disasters. It will also alleviate suffering by providing timely and appropriate response mechanisms for disaster victims.

In conclusion, partnerships with regional organizations, development partners, civil society, and the private sector enable a coordinated approach, which includes disaster risk financing, early warning systems, risk assessment, and disaster preparedness. The Government of Kenya is committed to working with all regional partners in finding lasting solutions to common disaster risk challenges.

TOPIC 1:

SEISMIC RISK IDENTIFICATION

KEY MESSAGES

THE EARS REMAINS SEISMICALLY ACTIVE.

In the 20th century, the region around the EARS experienced at least seven events of magnitude-6.0 to 7.5, triggering significant building collapse, infrastructure damage, and casualties.

RAPID URBANIZATION IN SUB-SAHARAN AFRICA MEANS FUTURE EARTHQUAKES ARE LIKELY TO HAVE A GREATER IMPACT THAN HISTORICAL EVENTS.

The Sub-Saharan population tripled between 1980 and 2018. It is expected to double by 2050. As a percentage of total population, the share of population living in urban areas was approximately 22 percent in 1980, and it is expected to rise to more than 55 percent by 2050 (World Bank 2017).

THE APPLICATION OF SCIENCE IS KEY TO EFFECTIVE POLICIES AIMED AT REDUCING DISASTER RISK.

Identifying risk is a fundamental step for building design and construction regulation and enforcement. Crucial risk identification activities include the development of national seismic hazard maps and the assessment of building and infrastructure vulnerabilities.

TECTONIC CONTEXT AND HISTORICAL SEISMICITY

Professor Atalay Ayele, *Addis Ababa University*

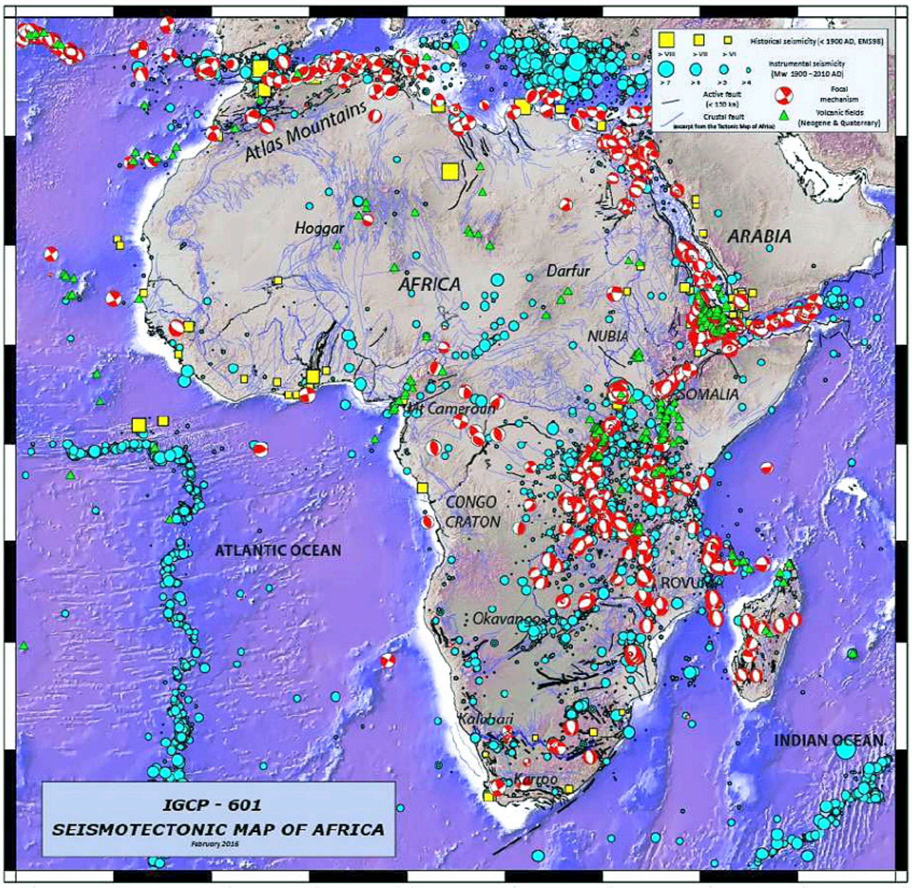
Notably destructive seismic events in the EARS include the magnitude-6.1 Toro earthquake of March 1966; the magnitude-7.0 Mozambique earthquake of February 2006; and the Southern Sudan tremors of May 1990, of magnitude-7.1 and magnitude-7.2, respectively.

Unfortunately, the Rift System is probably the least monitored on the planet. There is also no institutional network in place for mitigation purposes in many African countries. Monitoring facilities are scarce, and the capacity of research institutes, especially in terms of equipment, is limited.

As a result, the Sub-Saharan African population is not sufficiently aware of the threats posed by seismic activity in the region and is unprepared to face such natural hazards. National development could be crippled by an earthquake of magnitude greater than 7.0, which is possible in future. With the current boom in information and media, proper outreach and risk awareness must be considered.

A priority should be to map seismic hazard to better mitigate risk, leveraging existing data provided through such means as earthquake catalogues, active faults databases, ground motion prediction equations, geodetic models, and geological and geotechnical information.

FIGURE 4: Seismo-tectonic Map of Africa



Source: Professor Atalay Ayele.

Seismicity in Africa (from Meghraoui et al. 2016). The discs and "beach balls" represent epicenters of historical earthquakes instrumentally recorded (magnitude greater than 4.0).

FRAGILITY OF THE BUILT ENVIRONMENT

Dr. John Macdonald, *Bristol University*

Earthquakes don't kill people. Collapsing buildings do. By reducing the fragility of the built environment, the risk posed by seismic events may be mitigated. Damage to buildings is primarily influenced by factors such as construction material (such as unreinforced masonry, wood, reinforced concrete, steel frame), building height (number of stories), and other design characteristics (soft story, building shape, type of foundations, connection between walls, and so on).

Assessing the fragility of buildings is intrinsically associated with uncertainties. However, engineers can estimate the probability of building collapse if they know the building and soil characteristics.

Various design codes (e.g., ATC, Eurocode, BS) and guidelines exist. Unfortunately, they could be difficult to follow in practice, such as not being adapted to the construction materials available in the country or local building practices.

EXPOSURE GROWTH AND RISK MODELLING

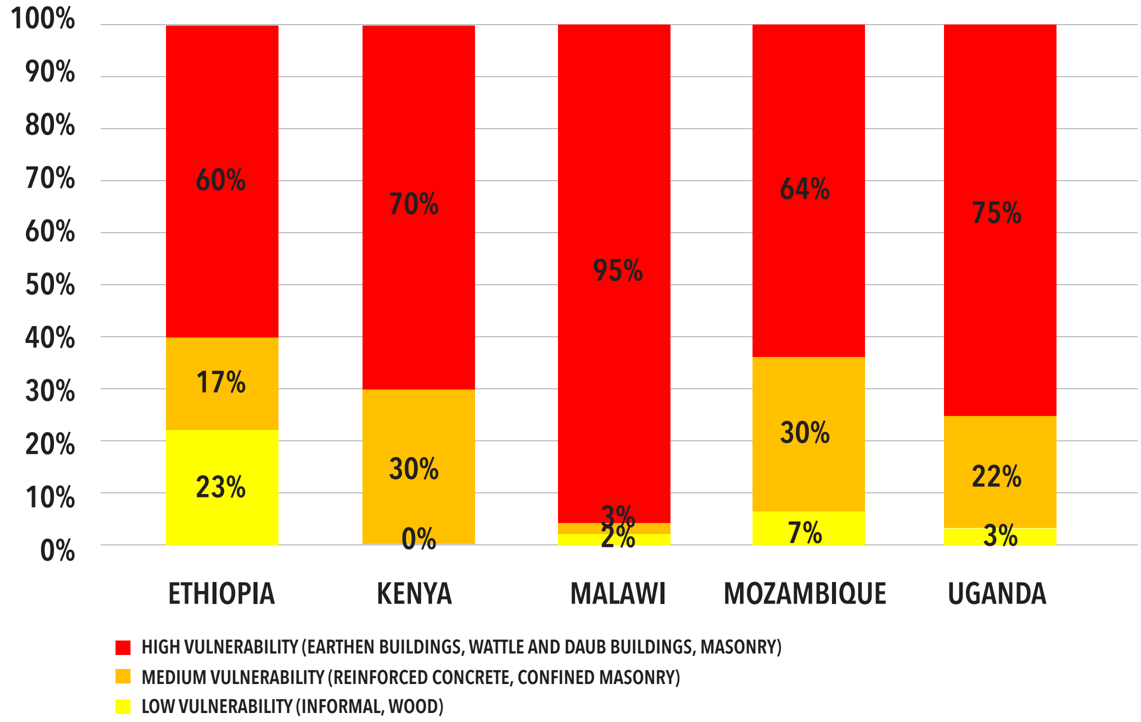
Dr. Ettore Fagà, *RED*

The fragility of the urban environment in the EARS is already a concern. **Figure 5** shows the current stock of buildings in select countries by estimated construction type and expected vulnerability. The results demonstrate that all five countries have buildings stocks with more than 60% earthen buildings, wattle and daub buildings, or masonry buildings, indicating a high potential vulnerability to seismic shaking.

Combined with the current vulnerability, rapid urbanization in Sub-Saharan Africa means future earthquakes are likely to have a greater impact than historical events. According to the World Bank's World Development Indicators, the Sub-Saharan population tripled between 1980 and 2018. It is expected to double by 2050. The share of people living in urban areas was approximately 22 percent of the total population in 1980, and it is expected to rise to more than 55 percent by 2050 (World Bank 2017).

To estimate the potential impact of seismic events, scientists have developed catastrophe risk models combining hazard (the likelihood of a severe ground-shaking event), exposure (the location and characteristics of assets at risk), and vulnerability (likely damage to assets) to estimate the potential losses from an earthquake in the EARS region (such as cost of repairs and casualties). **Figure 6** shows a good example of these effects through a modelling exercise conducted by the ERN/RED international consortium. The exercise indicated that reproducing the 1989 Salima District earthquake in Malawi (magnitude 6.2) would trigger approximately three times the reported economic losses if it were to occur again today. The fatalities would be nearly 65 times greater. These effects are mostly due to the rapid urbanization, which exposes underlying vulnerabilities. Similarly, a theoretical magnitude-5.0 earthquake occurring 50 km from Nairobi in Kenya could possibly trigger US$190 million in direct physical losses to the general building stock under current conditions.

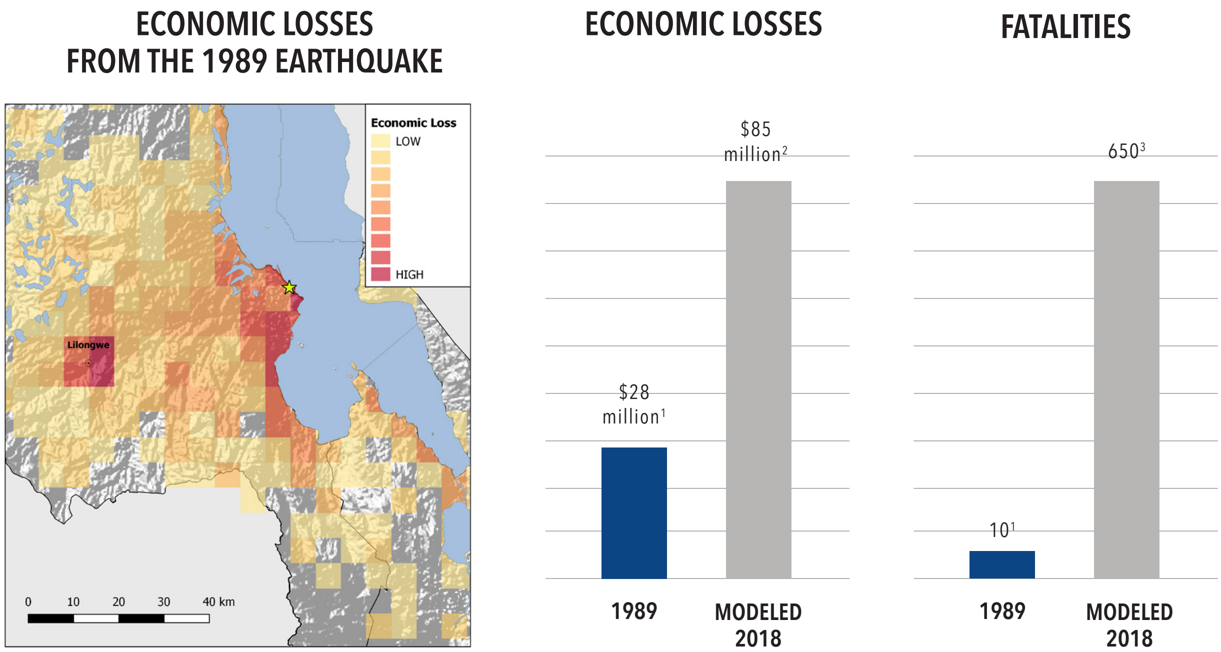
FIGURE 5: Vulnerability of Buildings in the EARS by Construction Type



Source: Dr. Ettore Fagà, RED. / Percentage of buildings by material class, Source ImageCat and expected vulnerability level, source RED/ERN

Impact from seismic events can be exacerbated by the relative vulnerabilities of buildings according to their type of construction. As this graph demonstrates, vulnerability to earthquakes varies across the EARS as a result of this.

FIGURE 6: Estimated Impact of the 1989 Salima Earthquake under today's conditions



[1] FROM EM-DAT CONSEQUENCE DATA [2] RANGE OF UNCERTAINTY 5.0=250.0 [3] RANGE OF UNCERTAINTY 120=1500

Source: Dr. Ettore Fagà, RED

According to a modelling exercise performed by ERN and RED, an "as if" scenario reproducing the 1989 Salima District earthquake in Malawi (magnitude 6.2) would trigger approximately three times the reported economic losses, if the event were to occur again today, and 65 times the fatalities, due to rapid urbanization.

SEISMIC HAZARD MAPPING AND BUILDING REGULATION

Luis Yamin Lacouture, *Associate Professor of the Department of Civil Engineering and Environment, University of Los Andes*

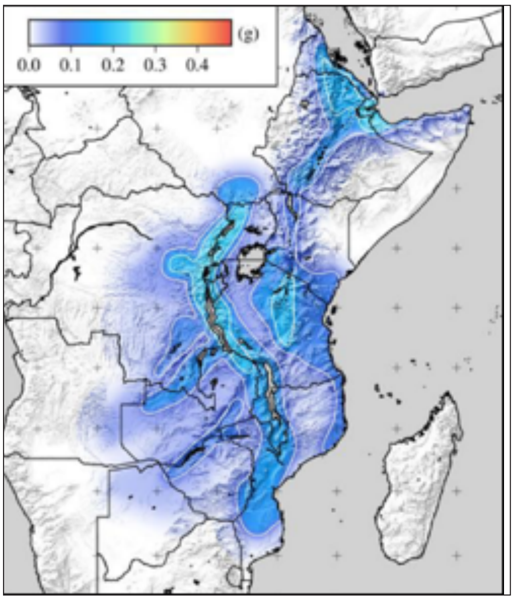
The application of science is key to the development of effective policies aimed at reducing disaster risk. Identifying risk is a fundamental step for building design and construction regulation and enforcement. Critical risk identification activities include the development of national seismic hazard maps and the assessment of building and infrastructure vulnerabilities.

As illustrated by international experience in countries like Colombia, appropriate regulation requires the collection of information about seismic intensity at rock level and local soil effects. Data required to conduct seismic hazard mapping include seismicity catalogs, the characterization of earthquake sources (for instance, crustal and subduction faults), and ground motion prediction equations.

Methodologies to assess hazard have been well established internationally over the past decades. So-called national "macrozonation" maps can help establish key regions of seismic hazard in a country, while microzonation maps can be developed to indicate the probable ground-shaking severity and the potential for landslides and liquefaction at the local level. These maps are crucial to inform seismic building codes and design spectra.

While important data gaps exist in Africa at the local level, preliminary seismic hazard maps are available at the regional level from various initiatives, such as the Global Earthquake Model (GEM) initiative. These maps could potentially support initial dialogues about the adaptation of building regulations. However, it is important to bring such maps into a country-owned and country-driven process, whereby stakeholders can understand, validate, and adapt them to the local context.

FIGURE 7: Example 500-Year Return Period Ground Acceleration Map for East Africa



Source: Global Earthquake Model (GEM) initiative.

Global Earthquake Model (SSAHARA Project, USAID), 1 in 500 years return period ground-shaking hazard map. While important data gaps exist in Africa at the local level, preliminary seismic hazard maps are readily available at regional level from various initiatives. These maps could support initial dialogues toward adapting building regulation.

TOPIC 2

RISK REDUCTION IN THE BUILT ENVIRONMENT

KEY MESSAGES

NATIONAL GOVERNMENT ROLES AND RESPONSIBILITIES.
National governments need to establish building land use regulation through basic legislation and building codes.

CAPACITY FOR IMPLEMENTING BUILDING CODES.
Countries must establish the capacity for implementation of building codes by allocating sufficient resources to core building control functions at the local level.

AN INCLUSIVE PROCESS.
The benefit of technical review and inspection should extend to the informal sector. Effective building regulatory regimes accomplish many social objectives beyond seismic resilience, including investment promotion, climate change mitigation and adaptation, historical preservation, and accessibility.

STRENGTHENING THE REGULATORY REGIME FOR BUILDING CODES: JAMAICA'S CASE STUDY

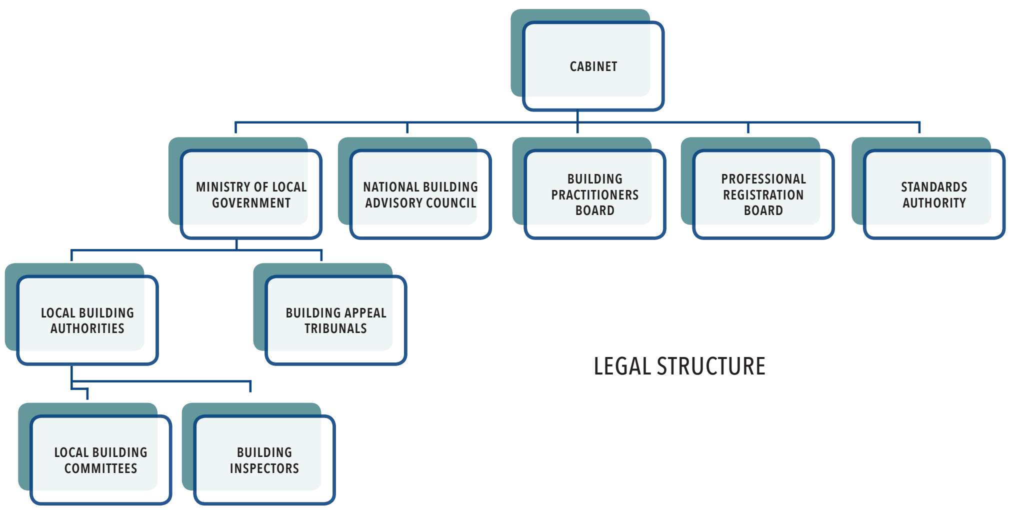
Richard Lawrence, *Standards Engineer at Bureau of Standards Jamaica*

The first building code in Jamaica was established for the parishes of Kingston and St. Andrews following the earthquake and fire of 1907. These regulations were based largely on contemporary British practices, which did not include seismic design. Since then, several unsuccessful attempts have been made to update the code; in the 1980s and 1990s, for example, there was a pan-Caribbean effort to create a Caribbean Unified Building Code (Cubic). It was determined then that the technical and managerial resources of the Caribbean region would not allow for independently maintaining a building code.

In 2002, under the leadership of Noel daCosta (President of the Jamaica Institute of Engineers and President of the Jamaica Chamber of Commerce and member of the Board of the Bureau of Standards), Jamaica opted to subscribe to the family of International Code Council building codes. Between 2002 and 2009, application documents for each code were developed on the basis of voluntary contributions from the professional community to provide the first comprehensive modernization of the Jamaican code. While this approach demonstrated the efficiency of adapting a model code to meet local needs, the code lacked legal status until the passage of the comprehensive Building Act in January 2018. The Building Code designated the Bureau of Standards as the authority responsible for the establishment and maintenance of the national Building Code of Jamaica. A significant feature of the Building Act was the establishment of the "Building Practitioners Registration Board," intended to include the informal building sector in the process of regulation for health and safety.

These three aspects–the adaptation from a model code; the inclusion of informal-sector builders; and the critical role of key leadership, particularly from the engineering community–may be considered for adoption by the states of the Rift Valley. However, what remains to be done is the comprehensive code-based training of regulators, building professionals, building practitioners, and artisans. For this purpose, a code training consortium has been formed under the leadership of the Bureau of Standards Jamaica (BSJ) and the Ministry of Local Government.

FIGURE 8: Reporting Lines for Jamaica's Building Regulations



Source: Strengthening the Regulatory Regime for Building Codes: Jamaica's Case Study / Permission: Richard Lawrence.

SEISMIC RISK REGULATION IN COLOMBIA

Luis Yamin Lacouture, *Associate Professor of the Department of Civil Engineering and Environment, University of Los Andes*

Colombia has significant exposure to seismic risk. Earthquakes in the cities of Popayán (1983) and Armenia (1999) led to major mitigation measures: in 1984, the first nationally mandated earthquake building regulations were introduced, based on the U.S. National Earthquake Hazard Reduction Program (NEHRP) Recommended Earthquake Provisions–Applied Technology Council (ATC-3). This code and subsequent updates in 1998 and 2010 have been supported by the Colombian Association of Earthquake Engineering.

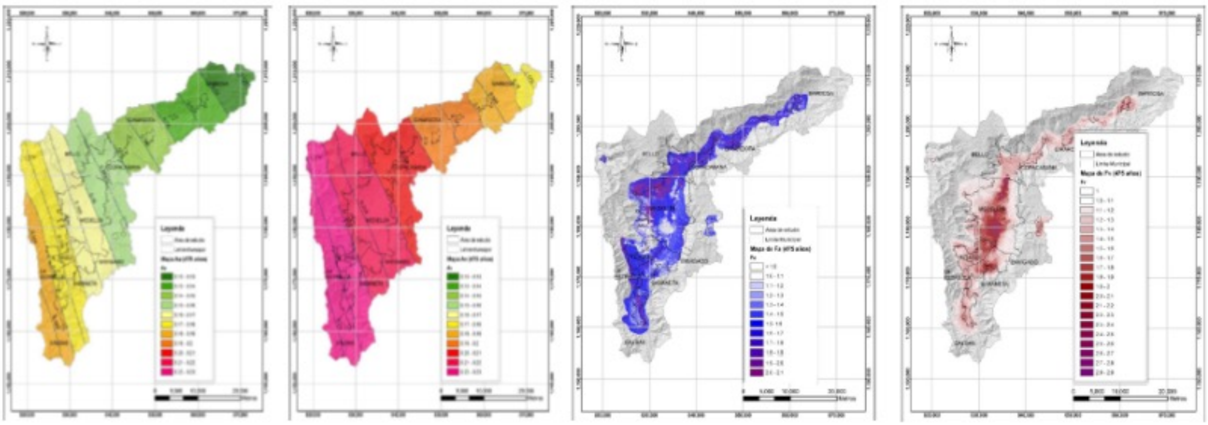
However, 60–70 percent of structures in Colombia are still not constructed with the benefit of regulatory oversight (World Bank 2013), and specific emphasis is now being placed on support for code compliance in the informal building sector. In addition, Colombia has developed a modern national seismic risk map defining three zones of high, medium, and low seismicity. Importance factors for structural types are assigned on the basis of exposed occupancy and the importance of post-disaster function.

Distinctive aspects of the Colombian code include:

- national seismic hazard maps for different return periods and structural periods;
- simplified standards for one- and two-story buildings;
- implementation of private-sector "third-party" plan review and inspection;
- subsidies for seismic retrofit of existing residential buildings; and
- city seismic microzonation mandatory for urban areas with over 100,000 inhabitants.

Documents associated with the development of the Colombian seismic risk reduction program are available for reference.

FIGURE 9: Seismic Microzonation in Medellin



Aa-Rock **Av-Rock** **Fa-Soil** **Fv-Soil**

Source / Permission: Luis Yamin.

BUILDING AND LAND USE REGULATION

Thomas Moullier, *Senior Urban Specialist, World Bank*

Investing in an effective building regulatory system should be a strategic priority for rapidly urbanizing low- and middle-income countries. It is estimated that, globally, building stocks will double in the next two decades; in Africa, 50 percent of the continent's population will live in cities by 2030 (World Bank 2015). Much of this expansion is occurring in cities with limited capacity to ensure risk-sensitive development and construction and where the population density and lack of regulations increase the destructive potential of natural hazards.

Building and land use regulations are the most cost-effective tool for increasing people's safety at a large scale. To facilitate the construction of well-performing and resilient buildings, comprehensive regulatory frameworks are needed. Building codes can reduce vulnerability by specifying adequate standards for construction, and land use plans can reduce exposure by guiding development away from the most hazard-prone areas.

Various countries' experiences demonstrate the cost effectiveness of investing in a strong building regulatory framework. High-income countries such as Japan, for example, have developed incremental advances in building sciences that have been reflected in national seismic standards. There have also been incremental innovations in institutional processes for improved compliance. This has allowed vernacular and non-engineered construction to be recognized and regulated accordingly.

A well-functioning building regulatory framework can enable cost-effective construction in the following ways:

- Disaster and chronic loss reduction. In Ethiopia, for example, compliance with building code provisions could reduce average annual losses by 30 percent by 2050 (World Bank 2018).
- Continuity and growth in public revenues. Property tax revenues in several developing countries make up less than 1 percent of gross domestic product (as opposed to 2–3 percent of GDP in high-income countries; Merima et al. 2017).
- Improved investment and competitiveness. The cost of compliance and regulatory infrastructure is, on average, 1 percent of construction cost in developed economies.

The benefits of an effective building regulatory framework can also extend beyond disaster risk reduction to address several societal objectives, including accessibility and climate change adaptation and mitigation. These are reflected in figure 10, which describes the reach of the World Bank's Building Regulations for Resilience Program.

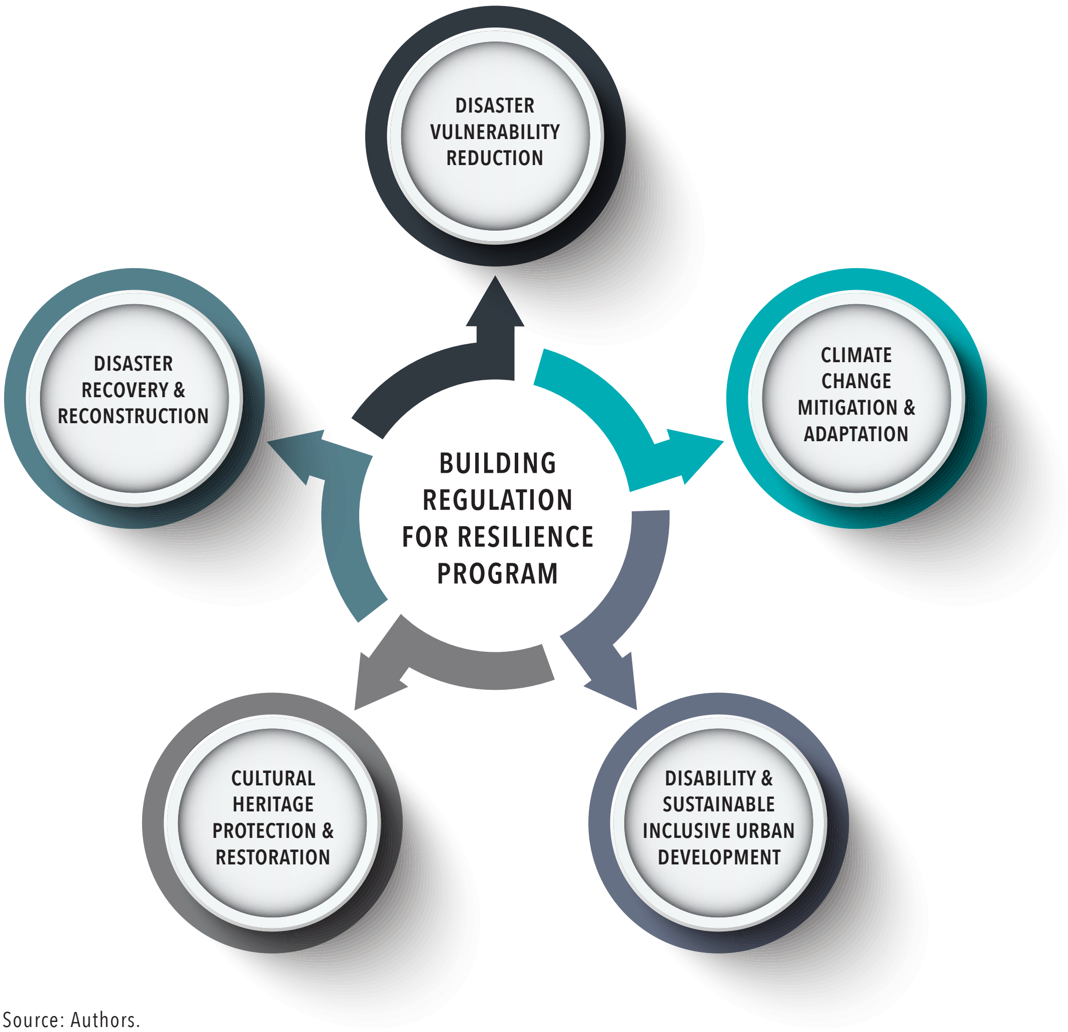
The program has a well-established framework and series of tools to help countries initiate regulatory reform. In scope, it addresses regulatory transformation at all territorial scales, enabling national-level legislation and institutions; national- and municipal-level building code development and maintenance; and local implementation at municipal level. It also ensures the support of key institutions and sectors.

The program has developed a Building Regulatory Capacity Assessment (BRCA) to establish a baseline from which to prioritize reform investments. The BRCA adapts the multi-scalar approach of framework development to context-specific regulatory dynamics. The program is currently working with more than ten countries to support this agenda.

In conclusion, eight actions should be prioritized for the development of an effective building regulatory reform agenda across formal and informal sectors:

- Develop national institutions.
- Promote technical innovation.
- Orient reforms toward compliance advice and support.
- Create and adapt standards appropriate to the urban poor.
- Streamline regulatory processes.
- Support education and vocational programs.
- Enhance resilience of vernacular constructions.
- Promote local building products.

FIGURE 10: Building Regulation for Resilience Program Structure



Source: Authors.

TOPIC 3

RESILIENT INFRASTRUCTURE

KEY MESSAGES

UNDERSTAND THE LIKELY IMPACTS OF HAZARDS ON INFRASTRUCTURE.

To ensure that infrastructure systems continue to serve their purpose of sustaining or enhancing living conditions and supporting economic activity, it is critical to understand the likely impact of a range of hazards on each type of system. It is also important to understand the interdependencies among different types of systems in a complex world. The impact of a natural hazard on one system may have complex effects on and cause cascading failures in other systems.

AN INFRASTRUCTURE ASSESSMENT CAN HELP ACHIEVE THIS.

It can provide a picture of the type, location, and value of infrastructure at risk to understand the exposure and vulnerability of these assets. Probabilistic risk assessments such as CAPRA are used to understand the different types of damage and loss, both direct and indirect, from likely hazards.

WITH THIS INFORMATION, RISK REDUCTION AND PREPAREDNESS IS POSSIBLE.

These assessments may be used as the basis for the development and implementation of seismic mitigation measures, including the replacement, retrofitting, or maintenance of affected infrastructure.

UNDERSTANDING THE SEISMIC VULNERABILITY AND EXPECTED BEHAVIOR OF CRITICAL INFRASTRUCTURE COMPONENTS AND NETWORKS

Luis Yamin Lacouture, *Associate Professor of the Department of Civil Engineering and Environment, University of Los Andes*

Infrastructure describes the facilities, commodities, and systems required for an economy to function adequately and sustain or enhance living conditions, from the local or municipal to the national or regional levels. It generally consists of two types of systems: critical network systems, like transport, communications, energy, and water, and critical components systems, like health and education.

Historical case studies demonstrate the wide variety of behaviors of these systems under various types of hazards, and how they may be destroyed or damaged. Such examples serve as a pointer to how such losses may be avoided or their worst impacts mitigated.

FIGURE 11: Seismically Damaged Critical Infrastructure

Source / Permission: Luis E. Yamin.

Historical seismic events provide valuable information about the likely impact of future activity on similar infrastructure.

To understand the exposure and vulnerability of infrastructure systems, it's necessary to understand both the interaction between various types of natural hazard and types of infrastructure and to grasp the interdependencies among the complex systems that characterize the contemporary world.

While contemporary complex infrastructure systems are essential to support modern society's functions, the scale of these systems increases their exposure, and the increased interdependence necessary for optimized operation increases their vulnerability. In addition, many have reached an accelerated phase of aging and deterioration. This combination of factors creates the potential for cascading failures, which may be best understood using the following tools: Hazard and Action Component (HAC); Systemic Damage Propagation; Cascading Failure Assessment; Interdependencies Damage Propagation; and Systemic Performance Assessment.

In Ecuador, an infrastructure assessment measured the exposed value of infrastructure per region and the replacement value per type of infrastructure. The first step was to detail each component of infrastructure using geographic information system (GIS) data, giving its location, description, and characteristics and replacement value. Primary and secondary roads proved by far the most expensive components to replace, followed by hydraulic systems and oil pipelines.

The next phase will document the main natural hazards affecting each system, while the third phase will map the interdependencies among the systems.

INFRASTRUCTURE SYSTEMS RISK ASSESSMENT, MITIGATION, AND RESILIENCE MEASURES

Luis Yamin Lacouture, *Associate Professor of the Department of Civil Engineering and Environment, University of Los Andes*

Risk assessments of infrastructure systems measure the probability of reaching or exceeding a given impact to the system. Physical damage to components is one such impact; others include direct economic losses due to repair costs; disruption time, which may be exacerbated by the propagation of systemic damage and of cascading failures; indirect losses as a result of interdependencies among components or types of infrastructure; and third-party impacts.

These impacts may be assessed according to the likely hazards to which infrastructure is subject, its exposure, and its vulnerability using CAPRA, a probabilistic risk assessment platform. The risk assessment enables risk management measures to be put in place, including risk mitigation, financial protection, emergency response, and recovery. The risk assessment calculates average annual losses by considering the expected losses for all stochastic events and their annual frequency of occurrence. It also provides an indication of maximum probable losses, for a given return period of likely events.

Peru's public school infrastructure provides a valuable case study for a risk assessment conducted using CAPRA, which resulted in the development of a ten-year plan for upgrading its infrastructure, currently in implementation. Peru has 49,516 school facilities with 187,685 school buildings, accommodating 6.5 million students, 65 percent of them in rural areas (World Bank 2016). The 1996 Nazca earthquake caused extensive damage to this infrastructure but provided a valuable opportunity for the assessment of future risk.

As a starting point, it was established that buildings designed under the existing code (NSR 77) displayed a poor standard of seismic performance, which led to an update of the National Building Code (now NTE.030-98). Next, the probabilistic seismic hazard was calculated for various return periods, and the likely soil amplification effects for ground motion were calculated. An assessment was made of the various building typologies, from adobe to complex steel-frame buildings. The asset exposure and vulnerability were compared against a seismic hazard with several return periods, ranging from 31 years to 2,500 years.

Various types of buildings were lab tested at full scale to establish their vulnerability functions. Options were looked at for both retrofitting and replacing buildings against various average annual loss scenarios, and a cost-benefit analysis, reflected in Figure 12 through the comparison of benefit / cost (B/C) ratios, was performed for two reinforcement options—concrete shear walls and steel braces.

Interventions of US$6 billion were proposed for the seismic mitigation of the complete portfolio against a total value of assets of US$9 billion. Almost 140,000 buildings were proposed for interventions, with over 97,000 of those to be demolished, 40,000 to undergo retrofitting, and 2,700 to undergo maintenance.

School facilities were prioritized according to the scale of the necessary investment, the number of students each investment would benefit, and the extent to which risk would be reduced. This led to the adoption of the US$2.8 billion, ten-year School Infrastructure National Mitigation Plan for the replacement or retrofitting of all schools countrywide. Implementation of the plan is currently underway.

The Peru example provides a template for the implementation of Infrastructure Seismic Risk Mitigation Plans elsewhere, as outlined in the following recommendations:

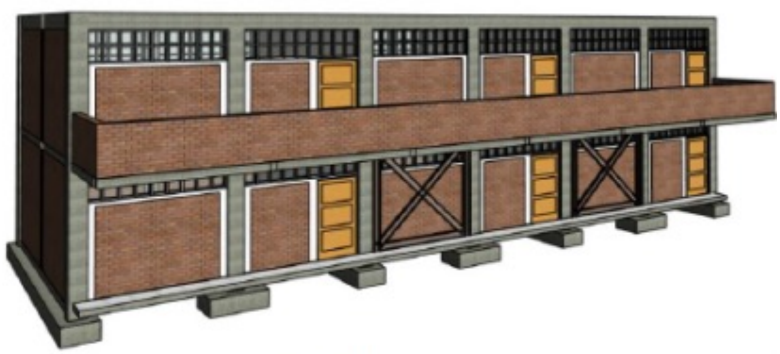
- Identify critical infrastructure systems, controlling hazards and potential interdependencies and consequences.
- Use GIS for critical components and network elements and their main characteristics.
- Conduct a hazard assessment for critical events and intensities.
- Conduct a vulnerability and risk assessment, estimating direct and indirect impacts on people, the economy, and the environment.
- Propose structural and nonstructural mitigation options through
- Performing B/C analysis;
- Selecting the most efficient options and prioritizing implementation; and
- Assessing cost and time of intervention.

Finally, there is an extensive literature for practitioners and governments to draw on of existing regulations, manuals, and guidelines for the design and implementation of resilient infrastructure.

FIGURE 12: Comparing Reinforcement Options with Cost-Benefit Analysis

CONCRETE SHEAR WALLS
B/C:1.5

Additional considerations:
– longer intervention time
– more complex procedures
– significant reduction in window areas (illumination)



STEEL BRACES
B/C:2.5

Additional considerations:
– no complex intervention to structural elements
– short instalation time
– higher benefit in terms of risk reduction (better performance)

Source / Permission: Luis E. Yamin

SITE VISITS

Three site visits provided physical context for the content of the workshop, showing the spectrum of building practices and solutions in a large city within the EARS. Participants were exposed to three different site typologies:

- A recent multi-storied building that incorporates contemporary seismic design principles and follows the most recent draft building code
- An older, large-scale building designed before the 1968 Building Code
- An informal settlement with non-engineered buildings that are structurally vulnerable and exposed to higher fire risk following earthquakes

KENYA'S NEW PARLIAMENT TOWER (UNDER CONSTRUCTION)

Location: *Central Business District*

Description: *Multi-storied (27 floors) frame structure. Building incorporates earthquake provisions and wind load dynamics into its structural design.*

FIGURE 13: Site visit at the new Kenyan Parliament Building in Nairobi

Source: Authors.

KENYA NATIONAL ARCHIVES AND DOCUMENTATION SERVICES BUILDING

Location: *Central Business District*

Description: *Former provincial headquarters building established in 1965 and still structurally sound.*

FIGURE 14: Kenya's old National Archives

Source: Authors.

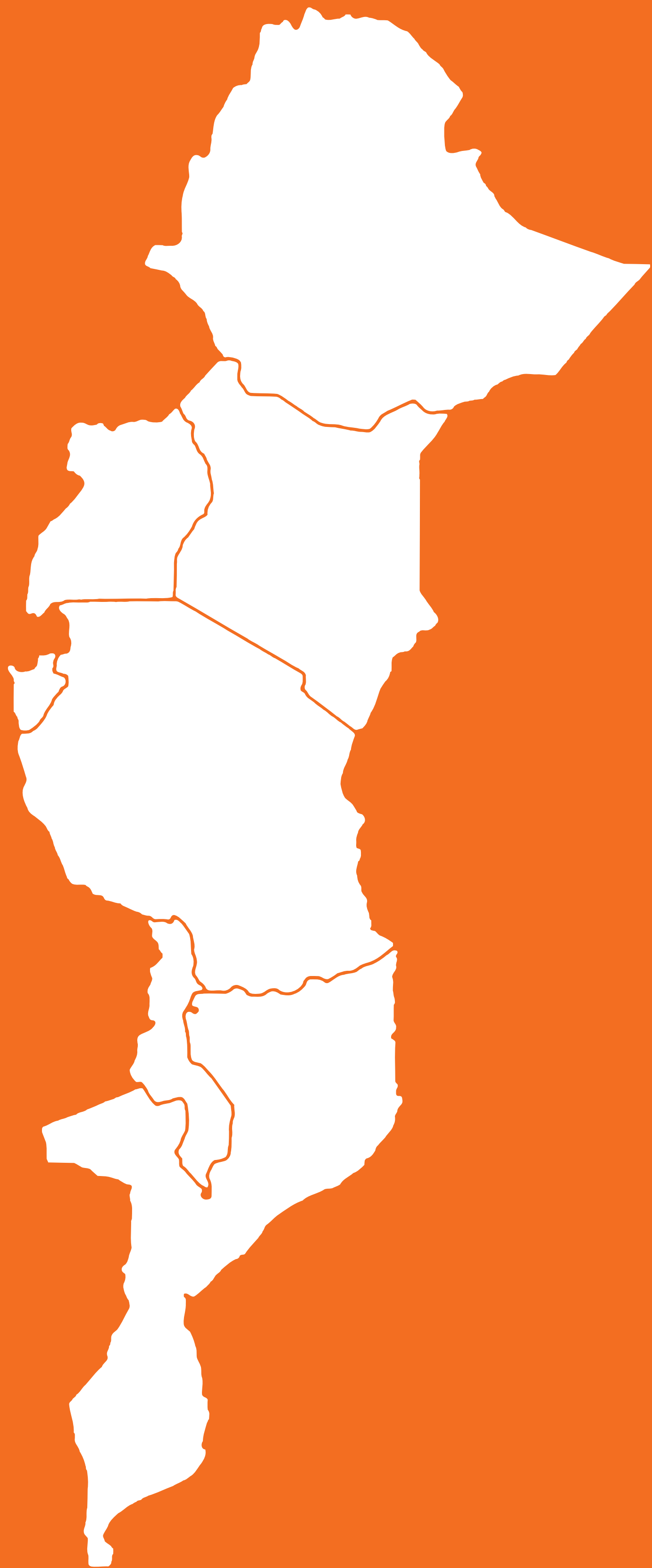
RAILWAY RELOCATION ACTION PLAN (RAP) FOR INFORMAL DWELLERS IN KIBERA SETTLEMENT

Location: *Kibera*

Description: *Relocation project for 10,000 dwellers in vulnerable structures to provide a safety corridor for railway operations. The project brings attention to the social, economic, and environmental impact of relocation on informal dwellers.*

FIGURE 15: Informal housing in Nairobi

Source: Authors.



CHALLENGE AND OPPORTUNITY PLANS AND CONCLUSIONS

KEY TAKEAWAYS

A MOMENT TO TACKLE REGULATORY FRAMEWORKS.

Across all six countries, current regulatory frameworks are either outdated or incomplete. All governments to a greater or lesser degree recognize this, however, and most are in the process of developing more robust regulatory frameworks.

ENFORCEMENT CAPACITY IS NEEDED.

Enforcement of existing regulations is challenging due to lack of capacity and conditions in the construction industry.

A FOCUS ON COORDINATION.

Better coordination across government departments and stakeholders is necessary for the improvement of existing legislation or the development of new regulations.

INNOVATION AND CREATIVITY ARE NEEDED TO MEET THE CHALLENGES.

Where resources and capacity are limited, innovative means are needed for sourcing technical and financial support, from institutional partners or the private sector.

ETHIOPIA

PRIORITY CHALLENGES

- Ethiopia's existing regulatory framework and its enforcement are generally weak. A history of limited professional capacity and budget has hampered the development of a consistent codification of building-related practices.

OPPORTUNITIES FOR INVESTMENT

- The government intends to strengthen the national regulatory framework of building codes, acts, and guidelines in the future. For example, with support from the World Bank, the Ministry of Urban Development and Housing has developed a city resilience diagnostic, which includes a review of the regulatory framework in ten cities across the country.
- This initiative will provide valuable data and reflections that directly feed into the creation of a national framework of regulatory initiatives.
- Ethiopia's "third-generation" building code has been endorsed and is currently being applied.

BARRIERS TO ACTION

- The country currently follows the Building Code Standards of 1995 but has been working on an updated building code since 2012, which is still being developed and in need of further detail.

SUPPORT NEEDED

- As part of Ethiopia's improvement of its regulatory framework, the government has considered engaging both the private sector and professional societies in the development of regulatory ecosystems and disaster management.
- This could supply much-needed technical expertise, as well as financial backing.

KENYA

PRIORITY CHALLENGES

- Government authorities agree that there is a need to develop implementable building codes in the short or medium term.
- The codes' effectiveness is directly linked to the inclusion of supporting disaster reduction and recovery (DRR) monitoring assets, like hazard maps and risk data.

OPPORTUNITIES FOR INVESTMENT

- Codes based on context-based data, particularly regarding the causes of risk, would strengthen national legislative frameworks through consistent integration.
- Kenya should seriously consider the inclusion of non-engineered buildings in building code development.
- Although informal construction is prevalent and difficult to categorize, incorporating vulnerable sectors into the development and application of codes would widen the scope of the country's regulatory capacity.

BARRIERS TO ACTION

- The current context shows there is a need for an improved legal structure that supports the implementation and enforcement of a new building code.
- Currently, the existing legislation is not up to date and its implementation is weak, whereas future legal frameworks should provide for the implementation of building codes that are applicable in the local context and adhere to national policies included in other laws and acts.
- A major challenge for the future will be coordinating currently disconnected sectors that are developing DRM-related policies and regulations.

SUPPORT NEEDED

- A better financial structure is essential; the government should be able to access sources of finance for the development of building codes, regulations, and technical support, particularly from existing development partners.

MALAWI

PRIORITY CHALLENGES

- Malawi has experienced a general failure in the development of regulations; the current iteration of the Malawi Code is a draft code that is not fully regulated.
- The first version of the document dates from 1997, and contains important omissions and sections that are now outdated and technically unsound.
- The building sector has usually been fertile ground for corrupt practices that have limited the consolidation or enforcement of effective codes.
- The country also faces limited technical capacity and training constraints, which hinder the development of appropriate adequate codes and building inspection capacities.

OPPORTUNITIES FOR INVESTMENT

- The current government understands the value of learning from existing good practices and codes for the development of appropriate legislation.
- This has led to acknowledging the importance of including professionals and nonprofessionals into the regulatory framework, to cover a wider spectrum of active stakeholders and participants in national building practices.

BARRIERS TO ACTION

- The burden of bureaucracy has made building timelines too long, and the lack of incentives has contributed to a high degree of informal construction and the proliferation of non-engineered buildings.
- The country also faces limited technical capacity and training constraints, which hinder the development of appropriate adequate codes and building inspection capacities.

SUPPORT NEEDED

- There is an interest in developing building regulation and standards in close partnership with academia and interested stakeholders, who can provide essential technical and financial support for the development of building regulations.

MOZAMBIQUE

PRIORITY CHALLENGES

- Mozambique has no single building code, but a series of documents that together provide the basis for a loose regulatory framework.

OPPORTUNITIES FOR INVESTMENT

- Updating national building regulations remains a central challenge for the government and should be part of a larger initiative to develop stronger DRR policies, to ensure successful risk reduction.

BARRIERS TO ACTION

- Currently, there is limited institutional coordination and difficulty in securing consistent funding, which limits the possibility of reforming building codes and regulations at a national level.

SUPPORT NEEDED

- Finding technical and financial support remains essential, and the government has tried to find opportunities for this through donor-supported programs.

TANZANIA

PRIORITY CHALLENGES

- Tanzania has experienced significant seismic activity, which has exposed the need for seismic-oriented technical development to properly inform appropriate regulations.
- Government authorities have acknowledged the necessity of developing and implementing a cohesive building regulatory framework which is supported by additional, related legal systems, such as a Building Act and a National Building Code.
- No building code has been adopted in Tanzania to date.

OPPORTUNITIES FOR INVESTMENT

- Government officials are eager to develop a new code in the coming years. The Building Act has been drafted by the government, as a sign of political will to adopt stronger standards.

BARRIERS TO ACTION

- There are considerable knowledge gaps in developing building regulations, and collaboration with partner states and institutions who have succeeded in developing strong regulatory frameworks is essential moving forward.
- The lack of funding and technical expertise has also been a constant.

SUPPORT NEEDED

- Availability of funding can improve the government's capacity to train professionals and find supportive partners with regulatory knowledge and DRR experience.

UGANDA

PRIORITY CHALLENGES

- Historically, Uganda has suffered from a lack of consensus for the development of integrated frameworks. This includes building code regulations and acts, which are outdated and difficult to enforce due to several constraints.
- Uganda's existing regulatory framework consists of several pieces of legislation that provide legal context and background for construction, rather than an integrated building code.

OPPORTUNITIES FOR INVESTMENT

- While not exhaustive, the current code does provide a reference to some degree for a new regulatory framework.
- There is a clear need to strengthen regulatory systems and encourage any channels or opportunities that might support their development.
- A new code should simplify building requirements and regulate informal buildings accordingly.

BARRIERS TO ACTION

- As expected, limited access to exclusive finances for developing regulatory frameworks is a major challenge.
- Similarly, human resources for the adequate training of professionals in charge of developing regulatory systems and DRM initiatives are scarce.

SUPPORT NEEDED

- Access to finance and capacity building are two areas where Uganda would benefit from private-sector and institutional support.

ANNEX:

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Ettore Fagà is currently project manager for seismic hazard and risk analyses at RED. Since he joined RED in 2013, he has been working on the development of earthquake risk models. From 2009 to 2013 he collaborated with the European Centre for Training and Research in Earthquake Engineering (EUCENTRE, Italy) on the development of different research projects about seismic design and assessment of buildings and industrial facilities. In 2012 he was involved in field inspections after the Emilia-Romagna earthquake with the Italian Department of Civil Protection. In 2009 he was Site Manager Assistant at Consorzio Forcase (L'Aquila) for the C.A.S.E. project, including the development of 185 seismically isolated buildings after the 2009 L'Aquila earthquake. He holds PhD and MSc degrees in Earthquake Engineering and Engineering Seismology from the Institute for Advanced Study (IUSS) in Pavia (Italy).

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Richard Lawrence currently serves as Interim Director of the Engineering Division at the Bureau of Standards Jamaica. In this capacity, Mr. Lawrence has oversight of the Civil Engineering, Electrical/Electronic, and Mechanical Engineering Departments. Testing, calibration, and metrology activities are undertaken across these three areas. Mr. Lawrence holds a Bachelor of Science degree in Civil Engineering from the University of the West Indies, St. Augustine, Trinidad, and is currently pursuing a Master of Science degree in Sustainable Energy and Climate Change at the University of Technology, Jamaica. Richard has served on Jamaica's Building Code Steering and Technical Committees for the adaption of ICC Codes for Jamaica. He also led Jamaica's first train the trainer program to prepare professionals, regulators, and building practitioners to implement the Building Codes.

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John Macdonald is a reader in Structural Dynamics in the Earthquake and Geotechnical Engineering research group at the University of Bristol, UK. A graduate in Engineering Science from University of Cambridge in 1990, he was awarded the Institution of Civil Engineers' (ICE) student prize. He worked for engineering consultant Scott Wilson (now part of AECOM) in structural design. His PhD from Bristol in 2000 led to a solution to excessive vibrations of the Second Severn Crossing and an Institution of Civil Engineers prize. He has held an Engineering and Physical Sciences Research Council (EPSRC) Advanced Research Fellowship and is a Subject Editor of the Journal of Sound and Vibration. He led an Earthquake Engineering Field Investigation Team mission to Colombia, which focused on the performance of non-engineered buildings; he is currently leading the EPSRC Global Research Challenges Fund project "PREPARE: Enhancing PREParedness for East African Countries through Seismic Resilience Engineering."

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