german cooperation
DEUTSCHE ZUSAMMENARBEIT

Implemented by
giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

African Union

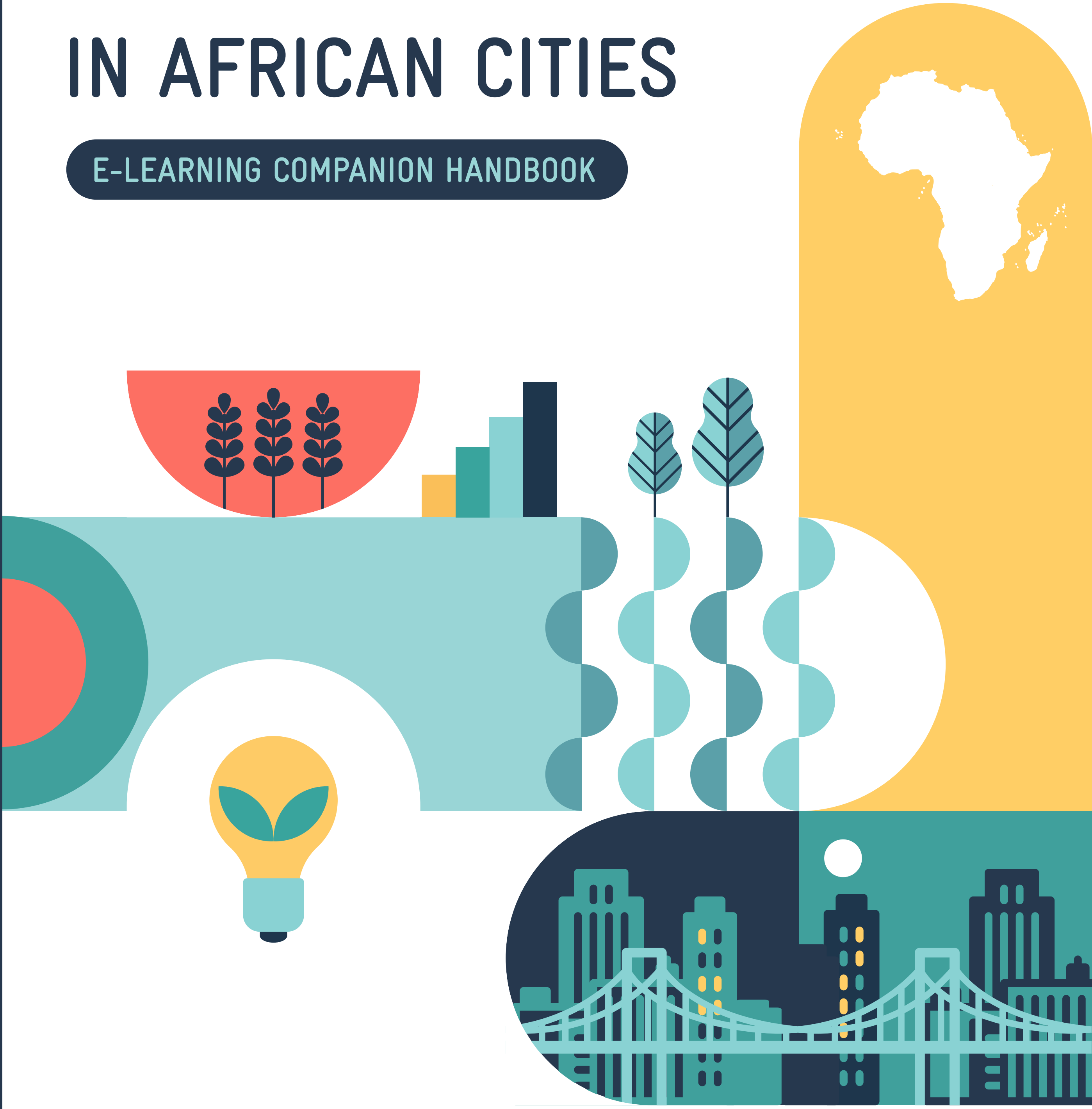
UNDRR
UN Office for Disaster Risk Reduction

sdi.

RIA
RESILIENCE INITIATIVE AFRICA

RISK-INFORMED URBAN DEVELOPMENT IN AFRICAN CITIES

E-LEARNING COMPANION HANDBOOK



atingi

Date: 2026

Table of contents

About This Handbook

This handbook provides a concise, text-based summary of the e-learning course Risk-Informed Urban Development (RIUD) in African Cities. It is designed for both offline and online use and is suitable for low-bandwidth environments, making it accessible to a wide range of users.

The handbook complements the digital course by summarising the key concepts presented in each module, highlighting practical insights and real-world examples, and using clear and accessible language throughout. Visual elements from the e-learning course, including infographics, diagrams, and maps, are referenced where relevant to support understanding and reinforce key messages.

Course Overview

African cities are among the **fastest-growing urban areas** in the world. Rapid urbanisation is increasing exposure to climate- and disaster-related risks, while also placing growing pressure on infrastructure, public services, and governance systems. Climate change further intensifies existing hazards, **including flooding, drought, heatwaves, storms, and sea-level rise**. At the same time, social and economic conditions play a crucial role in determining who is most affected by these risks, shaping patterns of vulnerability and resilience within urban populations.

Purpose of the Course

The purpose of this course is to provide foundational knowledge on Risk-Informed Urban Development (RIUD). It aims to support decision-makers in understanding urban risk in African contexts, integrating climate and disaster risk considerations into urban planning processes, and identifying practical entry points for action. In doing so, the course seeks to strengthen the links between urban growth, risk assessment, governance and financing, and both short- and long-term resilience measures.

Target Audience

This course is intended for a wide range of professionals involved in urban development and risk management. The target audience includes urban planners and municipal staff, as well as policymakers at local, regional, and national levels. It is also relevant for development practitioners and technical advisors, and for professionals working in the fields of climate adaptation, disaster risk reduction, urban development and housing, infrastructure, and public services.

Learning Approach

The course follows a self-paced, modular learning approach that allows participants to engage with the content according to their individual needs and schedules. It combines key concepts and definitions with case studies from African cities, as well as applied examples and practical reflections. Throughout the course, emphasis is placed on real-world relevance and decision-making contexts. The structure is designed to support both a coherent learning journey and continued use as a reference document after course completion.

Module 1: Introducing Key Concepts of Risk-Informed Urban Development

Purpose of this module

The purpose of this module is to build a shared understanding of how urban development processes create and shape risk, and why risk reduction is essential for achieving sustainable urban futures. The module introduces the core concepts that are used throughout the course and provides an overview of current urban risk patterns in Africa, as well as emerging trends linked to climate change and ongoing urban growth.

Urban Growth, Climate Hazards, and Unequal Risk

Figure 1. Urban residents are exposed to multiple climate-related risks in their daily lives.

Across many African cities, everyday life is increasingly shaped by the interaction between rapid urban growth, climate-related hazards, and social vulnerability. Light rainfall can quickly disrupt mobility, livelihoods, and access to markets, as streets flood and informal economic activities are forced to halt. For many urban residents—especially those working in exposed locations—even small weather events translate into lost income, damaged goods, and growing insecurity. These impacts are not caused by hazards alone, but are closely linked to where people live and work, and to how cities have developed over time.

Rapid population growth, weak infrastructure, poorly planned urban expansion, and the spread of informal settlements have increased both exposure and vulnerability across African cities. As urban areas expand, more people and assets are located in flood-prone zones, on unstable land, or in neighbourhoods lacking drainage, basic services, and adequate protection. At the same time, cities face a wide range of interacting risks, including floods, droughts, heatwaves, landslides, and storms, alongside pressures such as economic instability, conflict, environmental degradation, and loss of biodiversity. Climate change is intensifying these challenges by increasing the frequency and severity of extreme events, raising temperatures, and altering rainfall patterns, resulting in unequal impacts across communities and deepening existing vulnerabilities.

This module explores how urban development processes, climate hazards, and social conditions combine to create risk in African cities. By the end of the module, learners will understand how urban development unfolds and why risk reduction matters, be able to define and explain key risk concepts, and analyse the state and trends of risk across urban areas in Africa—laying the foundation for building safer, more resilient cities.

Rapid Urbanization in Africa

Africa is the fastest urbanizing continent in the world. Over the next thirty years, Africa's urban population is expected to grow at an unprecedented rate, effectively doubling the number of people living in cities. Data from Africapolis indicate that by 2050, the continent's urban population will rise from 704 million to 1.4 billion, with around two-thirds of Africans residing in urban areas. This rapid demographic shift is reshaping African cities and has significant implications for exposure to risk, infrastructure demand, and urban resilience.

Visit [Africopolis] for more information!

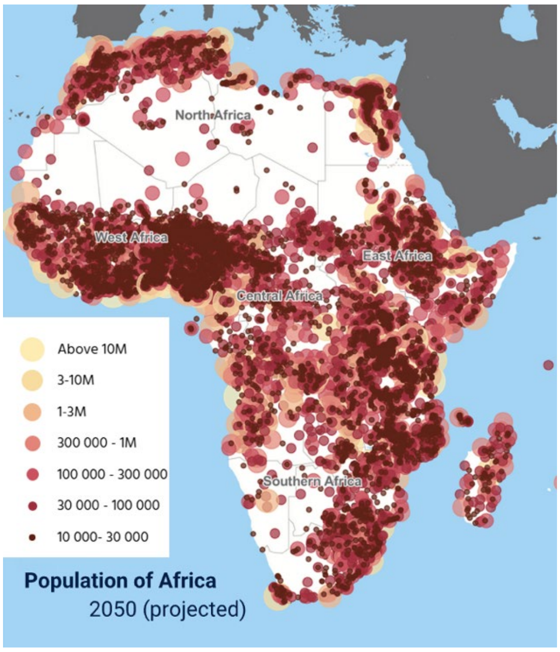


Figure 2. Population development of the African continent, projected for 2050

Risk in Africa

As African cities continue to grow, the demand for land, housing, infrastructure, and essential services is increasing rapidly. When urban expansion is poorly planned and informal settlements grow faster than services and infrastructure can keep up, many people are pushed into high-risk conditions. As a result, urban growth can place large segments of the population at greater risk, especially in areas exposed to climate hazards and lacking adequate protection.

Across the continent, cities are already experiencing the impacts of climate change. Although Africa is among the lowest contributors to global greenhouse gas emissions, climate-related hazards are increasingly affecting urban areas. Sea level rise, floods, extreme heat, droughts, dust storms, and heavy rainfall are already disrupting cities and are expected to become more frequent and severe in the future. These hazards interact with existing social and economic vulnerabilities, amplifying their impacts on livelihoods, health, and safety.

To better understand how these risks affect everyday life, the following video illustrates the situation faced by communities in Nigeria:
https://www.youtube.com/watch?v=KYBxTl3ZYsA

Climate Change and Urban Risk

Climate change is increasing the frequency and intensity of extreme weather events, while also creating new risks and exacerbating existing ones. In urban areas, these impacts are reflected in more frequent flooding and heat stress, growing water scarcity and drought-related impacts, and increased damage to housing, infrastructure, and livelihoods. Cities with weak planning systems and limited financial or institutional resources face the greatest challenges in responding to these pressures, further amplifying existing patterns of risk and vulnerability. For an overview of the different climate hazards impacts on African regions, see the IPCC's Sixth Assessment Report.

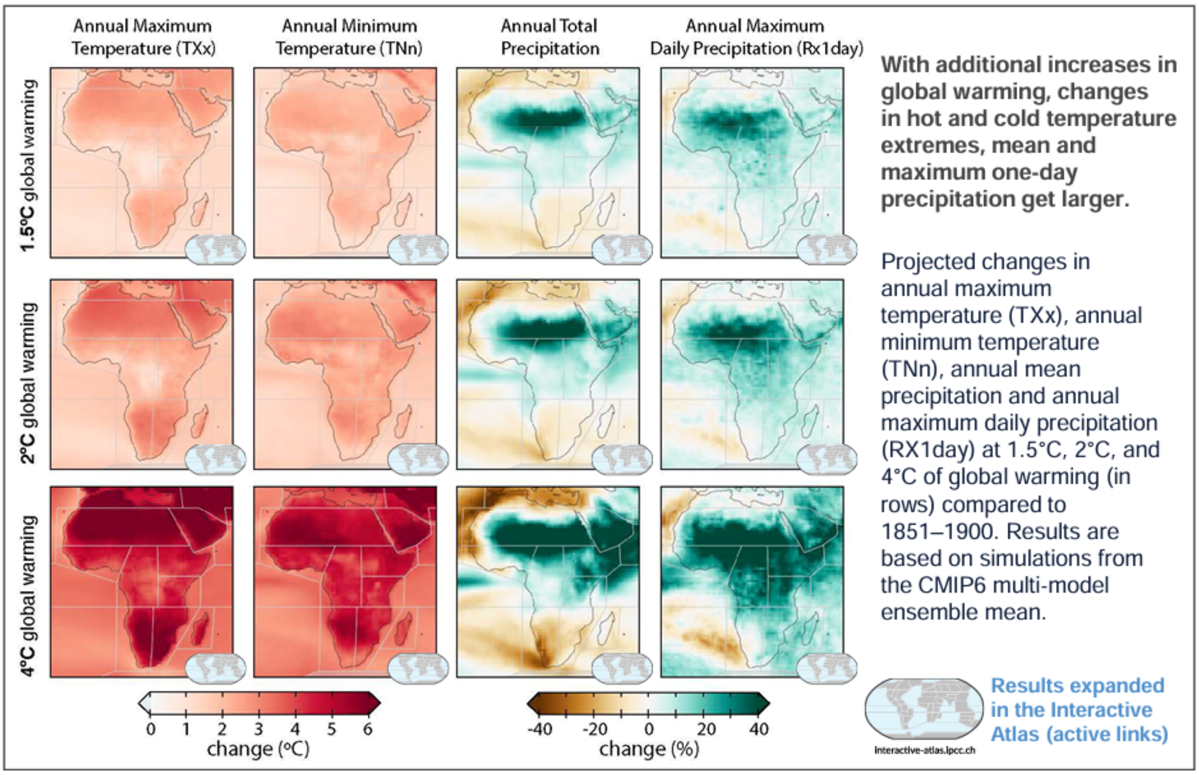


Figure 3. Climate change effects, by IPCC, IPCC proprietary licence / usage policy

Understanding Risk: Key Concepts

Hazards refer to potentially harmful events or processes that can cause damage or disruption in urban areas. In the context of African cities, these include climate-related hazards such as floods, droughts, heatwaves, storms, and sea-level rise. Cities are also affected by non-climate-related hazards, including conflict, economic shocks, and environmental degradation.

Exposure describes the presence of people, infrastructure, services, and economic assets in areas that are prone to hazards. As cities expand, more people and assets may be located in high-risk areas, increasing the potential for damage and loss when hazards occur.

Vulnerability refers to the social, economic, and physical factors that influence how severely people and systems are affected by hazards. These factors can include income levels, housing quality, access to services, governance arrangements, and social inclusion, all of which shape the capacity to anticipate, cope with, and recover from impacts.

Risk arises from the interaction between hazards, exposure, and vulnerability. It is not static but changes over time as urban areas grow, land-use patterns shift, and climate conditions evolve. Understanding risk as a dynamic process is essential for informed urban planning and long-term resilience building.

Linking Risk Concepts: From Capacity to Complex Risk Patterns

Building on the core concepts of hazard, exposure, vulnerability, and risk, it is important to further explore how different dimensions of risk interact and evolve over time. Urban risk is shaped not only by the presence of hazards, but also by the capacity of people, institutions, and systems to respond and adapt, as well as by the way risks accumulate and spread across interconnected urban systems.

Adaptive capacity refers to the ability of individuals, institutions, or ecosystems to adjust to climate impacts. This includes actions taken before, during, and after hazardous events, such as preparing in advance, responding effectively during an emergency, and recovering afterwards. In urban contexts, adaptive capacity can involve measures such as rebuilding homes after flooding, improving drainage systems, or strengthening early warning and response mechanisms. Higher adaptive capacity can significantly reduce long-term risk and losses.

Closely related to adaptive capacity is **sensitivity**, which describes the degree to which a system is affected when exposed to climate-related stressors. Even when two systems face the same hazard, their responses may differ considerably. For example, one road may crack during a heatwave while another nearby remains intact due to differences in materials, design, or maintenance. Sensitivity helps explain why impacts vary across locations and infrastructures exposed to similar conditions.

Resilience brings these elements together. In the context of disaster risk, resilience refers to the ability of a system, community, or society exposed to hazards to resist, absorb, accommodate, adapt to, transform, and recover from impacts in a timely and efficient manner. This includes preserving and restoring essential structures and functions through effective risk management. Resilience is therefore not only about recovery after a shock, but also about learning from past events and strengthening systems to better withstand future risks.

Understanding Complex Risk Dynamics

Urban risks rarely occur in isolation. Instead, they often interact across sectors, locations, and time, creating more complex risk patterns that can amplify impacts.

Systemic risk refers to cascading impacts that spread within and across systems and sectors through the movement of people, goods, capital, and information. A single hazardous event can trigger disruptions far beyond the initially affected area, potentially leading to widespread consequences or even system collapse over different time horizons. For example, flooding in one neighbourhood may disrupt transport, supply chains, or public services in surrounding areas, illustrating how interconnected urban systems transmit risk.

Figure 4. Illustration of systemic risk, where flooding impacts one area and triggers cascading effects across neighboring buildings and systems.

Compounding or accumulated risk occurs when multiple hazards affect a community in quick succession, before recovery from a previous event is possible. Repeated flooding events, for instance, can erode coping capacity over time, increasing losses and deepening vulnerability with each new shock. Compounding risk highlights the importance of recovery time and the cumulative nature of impacts.

Figure 5. Illustration of compounding risk, where repeated flooding events affect a community before recovery from previous impacts is possible.

Multi-hazard risk describes situations in which urban areas are exposed to several different hazards simultaneously or in close sequence. Cities may face combinations of flooding, heatwaves, storms, industrial accidents, or infrastructure failures at the same time. The interaction of these hazards can

Figure 6. Highways and industry being exposed to multiple hazards occurring simultaneously or in close succession.

intensify impacts and complicate response and planning efforts.

Case Study: Flood Risk Reduction through Nature-Based Solutions in Maputo, Mozambique

This case study highlights how flood-prone coastal communities in Maputo have addressed increasing climate risks by combining nature-based solutions with resilient urban infrastructure.

Maputo has experienced recurrent flooding during periods of heavy rainfall, severely affecting daily life in vulnerable neighbourhoods. Floodwaters regularly forced the closure of schools and local businesses, disrupted access to education, and damaged buildings that were not designed to withstand extreme weather events. These impacts disproportionately affected children and low-income households, increasing social and economic vulnerability.

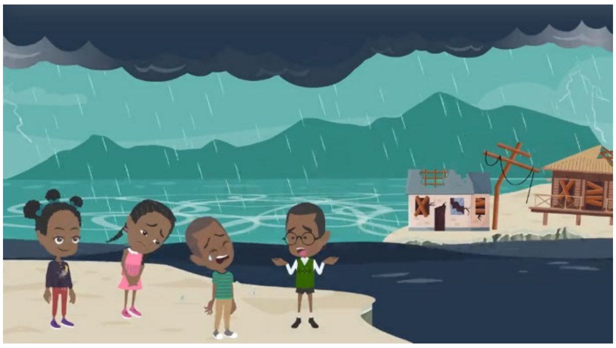


Figure 7. Flooding impacts on coastal communities in Maputo.

To address these challenges, local authorities partnered with UN-Habitat, the city administration, and local communities to implement integrated flood risk reduction measures. A central element of this approach was the restoration of mangroves along the coast. Mangroves act as natural buffers against storms by absorbing wave energy, slowing storm surges, and reducing flood intensity. Because mangroves thrive in brackish coastal environments, this solution was specifically tailored to local conditions.

In parallel, more resilient infrastructure was developed, including the construction of elevated schools designed to remain accessible and safe during flooding events. These measures ensured continuity of education while reducing damage to public buildings.

Figure 8. Restored mangroves and elevated buildings as integrated flood risk reduction measures.

Beyond physical infrastructure, the success of this initiative relied on collaboration across governance levels and sectors. Limited financial resources and technical capacity initially posed challenges, but international support and strong community engagement enabled the implementation of locally appropriate solutions.

Importantly, this case demonstrates that nature-based solutions not only reduce disaster risk but also provide long-term environmental and social benefits.

While mangrove restoration is particularly suited to coastal areas, similar principles can be applied elsewhere. In river basins or inland wetlands, ecosystems such as salt marshes and freshwater wetlands can play a comparable role in absorbing floodwaters and reducing risk. The Maputo experience illustrates the importance of tailoring risk-informed urban development strategies to local ecological and socio-economic contexts.

Disaster and Disaster Risk Management

A **disaster** is a serious disruption caused by the interaction of hazards with exposure and vulnerability, leading to human, economic, or environmental losses. Disasters occur when communities and systems are insufficiently prepared to cope with hazardous events. For example, a severe storm can damage homes and critical infrastructure in a city that lacks adequate planning, early warning systems, or resilient construction standards.

Disaster Risk Management (DRM) refers to the systematic processes of designing, implementing, and assessing strategies, policies, and measures aimed at reducing disaster risks. DRM focuses not only on responding to disasters after they occur, but also on prevention, preparedness, and risk reduction. Practical DRM measures may include installing flood early warning systems, strengthening emergency preparedness, and conducting regular emergency drills to improve response capacity.

A Holistic Approach to Risk-Informed Urban Development

Risk-Informed Urban Development (RIUD) requires a holistic approach that connects risk assessment, governance, financing, planning, and social inclusion. Rather than addressing climate and disaster risks in isolation, RIUD brings together multiple entry points that collectively strengthen urban resilience:

1) A foundational step in this process is conducting **climate risk and vulnerability assessments**. Understanding the specific risks a city faces is essential for effective climate adaptation and urban development strategies. These assessments rely on continuous data collection, local knowledge, and partnerships with scientific experts to identify priority risks and inform decision-making.

Figure 9. Representation of the Holistic Approach to RIUD in the online course.

2) Effective RIUD also depends on **multi-level governance and financing mechanisms**. Coordination across municipal, regional, national, and international levels helps ensure that risk-informed approaches are embedded in urban planning processes. Linking authorities horizontally and vertically enables coherent action, while innovative financing options—such as insurance schemes, public–private partnerships, and green bonds—support the implementation of resilience investments.

3) In parallel, **emergency response** plays a critical role in reducing the impacts of hazards when they occur. Emergency coordination, early warning systems, and the integration of local and Indigenous knowledge help protect communities and limit losses during extreme events.

4) Beyond immediate response, RIUD emphasizes **long-term resilient urban planning**. This includes planning and building cities that are better able to withstand future shocks through sector-specific actions such as nature-based solutions for flood and heat adaptation, sustainable water management to address shortages, and resilient housing principles like "build back better" using safer materials and community-driven planning processes.

5) Strong **urban planning frameworks** further support risk-informed development. Regulatory instruments, such as land rights reforms and spatial planning policies, help manage development in high-risk areas. At the same time, cutting-edge technologies—ranging from smart sensors and climate modelling to decentralized energy systems—can reduce costs, improve efficiency, and lower risk.

6) Finally, **inclusivity** is woven throughout all aspects of successful RIUD. Ensuring that vulnerable groups—including people with disabilities, youth, older persons, migrants, and displaced populations—are meaningfully included is essential. Gender-sensitive and participatory approaches, adapted to African urban realities, help ensure that resilience-building efforts are equitable and effective.

Key Barriers to Risk-Informed Urban Development

While Risk-Informed Urban Development (RIUD) offers significant opportunities to strengthen urban resilience, cities often face a range of barriers that hinder effective implementation. These challenges span planning approaches, institutional capacity, coordination, and financing, and must be addressed holistically to enable sustainable risk reduction.

Sector-Based Approaches: Risk reduction efforts often focus on individual sectors rather than addressing the urban system as a whole. This fragmented approach can limit effectiveness, as risks frequently transcend sectoral boundaries. Integrated strategies—such as combining regional flood management with green infrastructure—

can provide more comprehensive protection, particularly against upstream flooding that affects urban areas downstream.

Planning: Insufficient investment in resilience-oriented planning remains a major obstacle. In many contexts, limited spending on risk reduction reduces access to insurance and increases long-term disaster costs. Strengthening planning processes and prioritising proactive investment in risk reduction can help break cycles of destruction, debt, and recurring humanitarian crises.

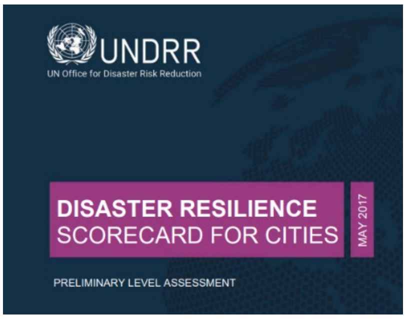
Institutional Coordination: Weak institutional coordination poses another significant challenge. Many cities lack comprehensive resilience plans, adequate budgets, or essential infrastructure. Strengthening city institutions, clarifying mandates, and improving coordination across departments and governance levels are critical steps toward overcoming these barriers.

Capacity Gaps: Urban authorities often face capacity gaps, including shortages of qualified staff and limited experience in designing and implementing resilience strategies. Challenges related to coordination, stakeholder inclusion, and enforcement of plans further constrain effective action. Addressing these gaps requires targeted capacity-building efforts and long-term institutional support.

Financial Constraints: Limited domestic financial mobilisation for risk reduction remains a key constraint. Governance gaps and fragmented financing systems can make it difficult for cities to access, coordinate, and effectively deploy available funding. Improving financial governance and expanding access to diverse funding sources are essential to enable sustained investment in resilience.

You want to assess your own resilience?

The UNDRR Disaster Resilience Planning Scorecard is a tool designed to help communities assess their readiness and resilience to withstand and recover from disasters. It provides a structured framework for evaluating various aspects of disaster risk management and resilience building.



Have a look at it here.

Key Takeaways: Understanding Urban Risk in African Cities

Urban risk in African cities extends beyond individual hazards. It is shaped by how cities grow, where people live, and how social, economic, and institutional systems interact with climate and disaster risks. Recognising this complexity is essential for improving responses, planning more effectively, and protecting those most at risk.

Key takeaways from this module include:

- **Urban risk is increasing** in African cities due to the interaction between rapid urban development and intensifying climate drivers.
- Risks are **systemic**, meaning they are interconnected across sectors and often disproportionately affect the most vulnerable groups.
- Effective risk reduction begins with **identifying who and what is most exposed** to hazards.
- Shifting from isolated, sector-based actions to integrated, city-wide strategies lead to **stronger urban resilience**.
- Reducing risk requires **collaboration across institutions, long-term planning, and targeted investments** in resilience.

Module 2: Risk Assessments

Purpose of this Module

This module introduces the foundations of risk assessment as a core component of Risk-Informed Urban Development. It explores what types of data are needed to assess hazards and risk, where this data can be sourced, and how practical risk assessment methods can be applied in real-world urban contexts. The module also highlights why integrating local knowledge into the assessment process is essential to ensure that risk analyses reflect community realities and lived experiences.

Why Risk Assessment Matters in Urban Contexts

Understanding climate risk in cities goes beyond identifying hazards such as floods or heatwaves. Risk is shaped by who and what is exposed, and by how vulnerable different groups and systems are. For instance, infrastructure designed for a “one-in-ten-year flood” may become unusable if extreme rainfall events occur more frequently, leaving critical services inaccessible.

Figure 10. Flooded streets in Kampala prevent access to schools.

In rapidly growing cities such as Kampala, these dynamics are particularly visible. Flooding can make roads impassable and prevent children from reaching schools in low-lying neighbourhoods, especially where urban expansion and hillside construction alter natural water flows. At the same time, heatwaves pose serious health risks, particularly for older persons, who may lack access to shade, clean water, or adequate healthcare. These examples illustrate that the same hazard can have very different impacts depending on local conditions and social vulnerability.

Figure 11. Extreme heat and air pollution disproportionately affect older people.

Combining Data and Local Knowledge to Understand Risk

Risk emerges from the interaction between hazards, exposure, and vulnerability, and its impacts are unevenly distributed across urban populations. As a result, effective risk assessments cannot rely solely on technical measurements, models, or maps. While quantitative data—such as flood extents, temperature projections, or hazard maps—are essential, they do not always capture the full range of impacts experienced by communities.

This module therefore emphasises the importance of combining quantitative data with qualitative insights derived from local knowledge and lived experience. Community perspectives can reveal hidden vulnerabilities, identify who is most affected, and provide context that numbers alone may miss. By integrating scientific data with local understanding, risk assessments can offer a more complete and actionable picture of urban risk. By the end of this module, you will understand what types of data are needed to assess hazards and risk, where relevant data can be sourced, how to apply a practical risk assessment method, and why local knowledge is a critical component of meaningful risk analysis in African cities.

Understanding Risk as an Interaction

Building on the core risk components introduced earlier, climate risk in urban environments emerges from the way hazards, exposure, and vulnerability interact in specific places. These elements must be considered together to understand why the same hazard can produce very different impacts across cities and communities. Risk can be expressed conceptually as a function of these interactions:

Climate Risk = f (Exposure, Hazard, Vulnerability)

This formulation highlights that risk is not fixed or inevitable. Changes in any one of these components—such as reducing exposure through better land-use planning, lowering vulnerability through inclusive policies, or mitigating hazards through climate adaptation measures—can reduce overall risk.

By analysing how hazards, exposure, and vulnerability interact in specific locations, risk assessments can move beyond generic hazard mapping and provide insights that support targeted, context-sensitive, and equitable urban risk reduction strategies.

Risk Assessment as a Multi-Dimensional Process

Risk assessment is a multi-dimensional process that combines different tools and perspectives. Some methods focus on numerical data and models (quantitative), while others draw on lived experiences and community knowledge (qualitative). Together, they help capture the full complexity of urban risk.

Qualitative Methods: focus on people's experiences, perceptions, and local knowledge. They are particularly useful for identifying vulnerabilities that may not be visible in datasets or maps. Common approaches include participatory mapping, focus groups, and the documentation of lived experiences during past events.

Quantitative Methods: rely on numerical data, indicators, and models to analyse hazards, exposure, and risk patterns. Examples include risk matrices, hazard and flood scenarios, indicators, and modelling tools, which support comparison, prioritisation, and evidence-based decision-making.

Combining qualitative and quantitative methods provides a more complete understanding of climate risk. While quantitative tools help identify where and how risks may occur, qualitative insights explain how these risks are experienced and who is most affected. Risk assessment is therefore not a one-time exercise, but a process that should be updated regularly and integrated into urban planning and budgeting to support long-term resilience.

A Practical Step-by-Step Approach to Risk Assessment

Risk assessment can be approached as a structured process that builds progressively from understanding hazards to evaluating overall climate risk. The following steps provide a practical framework that can be adapted to different urban contexts.

1) Identify Hazards

The first step is to identify all relevant climate hazards affecting the area of interest. This includes both hazards that are already occurring and those expected to intensify or emerge in the future due to climate change. Hazard identification should draw on a combination of scientific data, historical records, and community experiences to ensure that both documented events and locally observed risks are captured.

2) Assess Exposure

Once hazards have been identified, the next step is to determine who and what is exposed to them. This includes people, buildings, infrastructure, economic activities, and critical services. Exposure can be quantified using measurable indicators such as population density, asset counts, land-use data, or geographic information systems (GIS), which help identify where hazards intersect with urban assets.

3) Evaluate Vulnerability

Assessing vulnerability involves analysing how sensitive or susceptible exposed elements are to the impacts of hazards. This step considers social factors such as income levels, age, or access to services, as well as economic stability and the condition and strength of infrastructure. Understanding vulnerability helps explain why similar hazards may lead to very different outcomes across neighbourhoods or population groups.

4) Assess Climate Risk

In the final step, information on hazards, exposure, and vulnerability is combined to evaluate overall climate risk. This assessment can use quantitative tools, qualitative insights from experts and communities, or a combination of both. Conceptually, climate risk can be expressed as a function of these three components:

Climate Risk = f (Exposure, Hazards, Vulnerability)

The results of this step support prioritisation, planning, and decision-making, helping cities identify where action is most urgently needed to strengthen resilience.

(1) **(2)** **(3)** **(4)**

Figure12. Four-step process for climate risk assessment.

Case Study: Applying Risk Assessment to Flood Risk in Kampala, Uganda

This case study illustrates how climate risk assessment is applied in practice in Kampala to address recurrent flooding and guide targeted urban interventions. The city experiences frequent flooding during periods of heavy rainfall, particularly in low-lying neighbourhoods and former wetlands that have been increasingly built up as urban expansion continues. These conditions disrupt daily life, damage infrastructure, and disproportionately affect vulnerable communities.

Kampala Risk Matrix (Selected Hazards)

Hazard	Hazard type	Section
Flood	Climatological and meteorological	5.1
Human epidemic	Ecological and biological	5.5
Environmental degradation	Human-induced or technological	5.9
Water pollution	Human-induced or technological	5.9
Air pollution	Human-induced or technological	5.8
Fire and built environment	Human-induced or technological	5.4
Road accidents	Human-induced or technological	5.7
Drought/dry spells	Climatological and meteorological	5.2
Soil erosion	Geological	5.3
Food security/nutrition	Climatological and meteorological/human-induced or technological	5.6
Earthquake	Geological	5.4

Figure13. Risk matrix illustrating selected climate and non-climate hazards in Kampala.

A key starting point of Kampala's risk assessment process is the identification of multiple hazards. While flooding is the most visible threat, assessments also consider other interconnected hazards such as pollution, drought, and disease outbreaks. To capture this complexity, the city developed a risk matrix based on expert consultations, participatory ranking, and hazard evaluations. This approach links each hazard to its main drivers and helps reveal how human activities can amplify systemic risks.

Once hazards are identified, the assessment shifts focus from the hazard itself to who and what is most exposed and vulnerable. Rather than applying uniform solutions across the city, Kampala combines hazard information with data on exposure and vulnerability to prioritise action where it is needed most. This allows limited resources to be directed towards communities facing the highest risks.

Flood scenario mapping plays an important role in this process. For example, ten-year flood scenario maps are used to visualise potential impacts and guide decision-making. These maps support targeted investments, such as the installation of improved drainage systems in frequently flooded neighbourhoods, helping water move away safely and reducing risks to households, schools, and critical infrastructure.

Figure 14. Flood risk scenario mapping supports targeted investments in drainage and infrastructure.

A defining feature of Kampala's approach is the integration of quantitative tools with local knowledge and lived experience. Maps and models are complemented by community insights that help explain how risks are experienced on the ground. Stories from residents—such as children unable to reach school during floods—provide critical context that quantitative data alone may not capture. By combining scientific analysis with local perspectives, risk assessments produce a more complete and actionable understanding of urban vulnerability, enabling interventions that are both effective and socially responsive.

INFORM Subnational Risk Model

The Southern African Development Community (SADC) region faces increasing risks from floods, droughts, cyclones, and earthquakes, which are being intensified by climate change. These risks are shaped by a combination of geographical conditions, climate pressures, and economic factors. Strengthening risk data and modelling is therefore essential to support development, security, and sustainable growth while reducing poverty across the region.

The INFORM Subnational Risk Model is a risk assessment tool developed for the entire SADC region that provides detailed analysis at provincial, municipal, or comparable subnational levels. It allows decision-makers to assess and compare risk within a single country or across regions, supporting more targeted and evidence-based planning.

The model is being implemented and rolled out in the SADC region through the **Resilience Initiative Africa (RIA),** in collaboration with the **Southern African Development Community (SADC) Secretariat.** By combining hazard, exposure, and vulnerability data, the INFORM Subnational model supports decision-making for disaster preparedness, response, and development programming, particularly in contexts where resources are limited and risks vary significantly within countries.

A full training package is available that explains how to build and use an INFORM Subnational Risk Index to support disaster risk management and development programming.

Click here to access the training.

Other Risk Assessment Methods

In addition to qualitative and quantitative risk assessment approaches, cities can use a range of complementary methods to better understand current and future climate risks.

Spatial modelling uses maps, geographic data, and advanced analytical techniques to show where climate risks are concentrated. These tools help cities identify spatial patterns, visualise potential impacts, and design targeted adaptation strategies for specific neighbourhoods, infrastructure, or population groups.

Another important set of tools includes **socioeconomic pathways and scenario narratives, such as Shared Socioeconomic Pathways (SSPs) and Representative Concentration Pathways (RCPs)**. Risk does not exist in a vacuum; it is shaped by economic, social, and political developments over time. Scenario methods help explore different possible futures, for example whether a city invests in resilience, whether emissions rise or fall, and how climate impacts may evolve under different development pathways. These narratives support long-term planning by helping decision-makers prepare for a range of plausible risks. Further information on SSPs and RCPs is available here.

Purpose of Using Additional Methods

Together, these additional methods allow cities to combine spatial analysis, future trends, and expert projections to make risk assessments more robust and forward-looking. They help planners move beyond current conditions and anticipate how risks may change over time.

For a wider range of methods and tools that may be relevant for different urban contexts, cities can consult this open-access database:

https://cramse.adaptationcommunity.net/

Key Takeaways: Risk Assessments in African Cities

Urban risk in African cities is shaped by the interaction between climate hazards, exposure, and vulnerability, and by how cities grow and develop over time.

Understanding and assessing risk is essential for planning effective, inclusive, and resilient urban futures.

Key takeaways from this module include:

- **Risk is an interplay of hazards, exposure, and vulnerability**, and cannot be understood by analysing hazards alone.
- Risk assessment is a **multi-dimensional process** that combines different tools, data sources, and perspectives to reflect complex urban realities.
- **Combining quantitative and qualitative methods** provides a more complete understanding of climate risks, capturing both measurable impacts and lived experiences.
- **Risk assessments need to be updated regularly and adequately financed**; otherwise, they risk becoming outdated and ineffective as urban conditions and climate risks evolve.

Module 3: Governance and Financing of Risk-Informed Urban Development

Purpose of this Module

This module focuses on the governance and financing dimensions of Risk-Informed Urban Development (RIUD). While understanding risk and assessing hazards are essential first steps, reducing urban risk ultimately depends on how decisions are made, who is involved, and how resources are allocated. The module explores how different levels and types of governance shape urban resilience, and why financing mechanisms are critical to turning risk assessments into effective action.

Why Governance and Financing Matter for Urban Resilience

Across African cities, risk is not only unevenly distributed—it is also unevenly managed. As seen in Accra, exposure to hazards such as coastal erosion is closely linked to planning decisions, institutional capacity, and investment priorities. Protective infrastructure, such as seawalls or drainage systems, is often concentrated in areas of high economic value, while other communities remain increasingly vulnerable.

Governance structures determine who gets protected, whose risks are prioritised, and how decisions are coordinated across sectors and levels of government. At the same time, financing determines how far protection can go, which measures are implemented, and whether risk reduction efforts are sustained over time. Without adequate funding, even well-designed plans remain unimplemented; without effective governance, investments may reinforce existing inequalities rather than reduce risk.

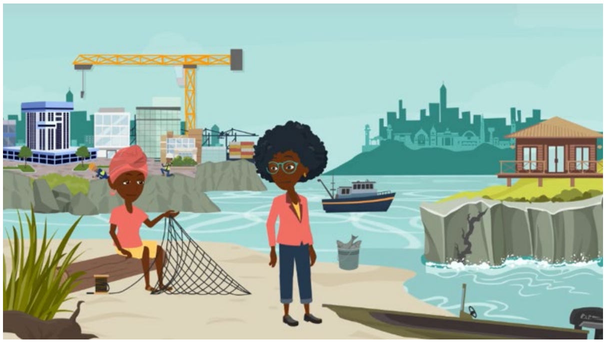


Figure 15. Coastal erosion and uneven protection in Accra.

From Risk Knowledge to Action

This module highlights the transition from understanding risk to acting on it. It examines how governance arrangements influence planning and decision-making, how responsibilities are distributed among institutions and actors, and how financial tools and budgets support—or constrain—risk reduction efforts. The module also emphasises the role of community capacity and inclusive processes in ensuring that resilience is not a privilege for a few, but a shared outcome for the city as a whole.

By the end of this module, you will understand how different levels of governance interact to manage urban risk, be able to identify key actors and institutions involved in risk-informed decision-making, and recognise how financing and budgeting practices shape the effectiveness and equity of urban resilience strategies.

GOVERNANCE

What Do We Mean by Governance?

In this course, governance refers to how public and private actors interact to make decisions for shared goals. It describes the processes through which different actors coordinate, negotiate, and act together to shape urban development and reduce risk.

This interaction takes place across different spaces and functions:

City halls represent the interaction between public authorities and other actors in setting priorities and making decisions that affect the city as a whole.

Legal buildings reflect the formal side of governance, including laws, rules, regulations, and monitoring mechanisms that guide and structure decision-making at different levels.

Meeting rooms highlight that governance is also a process of multi-stakeholder decision-making, where government officials, communities, civil society, and the private sector come together to discuss challenges and agree on solutions.

Planning offices illustrate the strategic dimension of governance, where resources such as finance and activity plans are allocated to support risk reduction and urban resilience.

Together, these elements show that governance is not only about institutions, but about **how decisions are made, who is involved in them, and how collective goals are pursued**.

Dimensions of Governance

Governance for climate risk management operates in two complementary ways:

Horizontal governance refers to collaboration across sectors, local teams, and communities working side by side. It emphasises sharing knowledge, responsibilities, and resources across actors at the same level.

Vertical governance describes how decisions and policies flow between levels — from national governments to city leaders and down to local communities. Effective vertical coordination ensures that strategies align across scales.

Governance Actors

Managing risk is a shared responsibility. **Every actor has a role**, including municipal departments, national governments, researchers, civil society organisations, and communities themselves. Effective governance brings these actors together so that cities can work collectively toward safety, inclusion, and resilience.

Figure 16. Governance actors involved in Risk-Informed Urban Development.

Inclusive Urban Risk Governance

Inclusive urban risk governance is essential to ensure that the interests, concerns, and needs of all actors and population groups within a city are recognised and addressed. Effective risk governance goes beyond technical planning; it actively seeks to include those who are most affected by climate risks in both assessment and decision-making processes.

An inclusive approach to urban risk governance involves:

- Involving marginalised and most vulnerable groups in risk assessments, ensuring their specific risks and capacities are recognised.
- Recognising women, children, and youth as key groups, as they often experience climate risks differently and disproportionately.
- Engaging communities directly in risk-related decision-making, rather than treating them only as recipients of information or interventions.
- Ensuring clear and accessible risk communication, using simple messages and multiple channels to reach diverse audiences.
- Leveraging information technologies and social media, including crowdsourcing tools, to gather local data and improve awareness.
- Promoting accessible e-governance platforms, designed to be user-friendly and easy to use, enabling broader participation in risk governance processes

Good climate in practice

This article presents **real-world case studies** from leading cities, showing how effective governance, smart decision-making, and cooperation across actors can help tackle climate risks more effectively.

Through practical examples, it illustrates how cities are improving coordination, planning, and investment to build **safer, more resilient, and greener urban environments**. The lessons shared can inspire policymakers, planners, and practitioners to strengthen climate governance in their own cities.

*Have a look at it **here**.*

Governance Dimensions in Urban Risk Management

Urban risk governance operates across multiple dimensions, reflecting how decisions are made, who is involved, and which areas of city life are affected. Understanding these dimensions helps clarify how governance functions in practice.

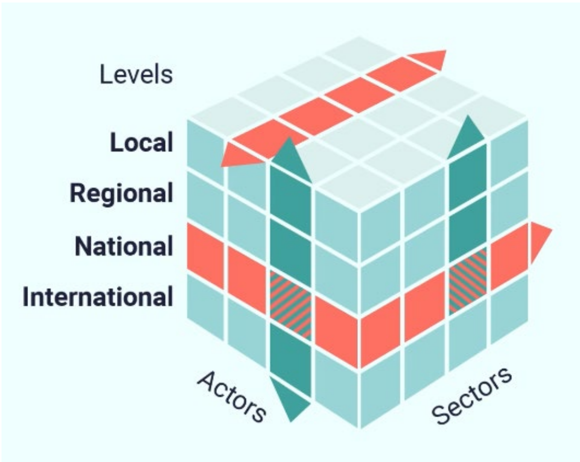


Figure 17. Governance dimensions in urban risk management.

Levels of Urban Governance: decisions related to urban risk management take place at different levels, including local, regional, national, and international. Effective governance requires coordination across these levels to ensure that policies and actions are aligned and mutually reinforcing.

Actors in Urban Governance: urban governance involves a wide range of actors, including governments, businesses, civil society organisations, researchers, and communities. Each actor plays a role in shaping urban decisions, contributing knowledge, resources, oversight, or implementation capacity.

Involved Sectors: risk governance also cuts across multiple sectors, such as environment, transport, construction, agriculture, and others. Since climate risks affect many aspects of urban life, coordinated action across sectors is essential to reduce vulnerabilities and build resilience.

Key Steps for Governance in Risk-Informed Urban Development

Now that we have a clear understanding of what governance means, we can look at how it works in practice. Governance for risk-informed urban development follows a series of connected steps that help cities organise decisions, resources, and responsibilities.

1. Create a City Vision and Mission: risk reduction often focuses on individual sectors rather than the whole urban system. A shared city vision helps promote integrated approaches—such as combining regional flood management with green infrastructure—to better protect cities from risks like upstream flooding.

2. Draft and Build Consensus on Policies and Plans: many countries invest too little in resilience, which increases disaster losses and recovery costs. Building consensus around risk reduction policies helps break cycles of destruction, debt, and humanitarian distress.

3. Elaborate Cycles of Urban Development Planning: many cities lack completed resilience plans, sufficient budgets, or essential infrastructure. Strengthening planning cycles, institutions, and resources is critical to address these gaps and improve long-term resilience.

4. Formulate Development and Resilience Strategies: urban authorities often face shortages of qualified staff and clear resilience strategies. Better coordination, stakeholder inclusion, and enforcement of plans are key to overcoming these structural challenges.

5. Define Roles and Responsibilities: domestic financial mobilisation for risk reduction is often weak, and governance gaps make it difficult for cities to access and coordinate funding. Clearly defined roles help improve accountability and resource management.

6. Elaborate Implementation Plans and Budgets: clear tasks, timelines, and budget allocations are essential to turn plans and strategies into concrete action.

Case Study: Freetown, Sierra Leone

Now that we have a clear understanding of what urban governance means and how different levels, actors, and sectors interact, this section explores how these principles work in practice. The case of Freetown illustrates how governance arrangements and financing decisions shape cities' ability to manage climate risks and build resilience.

Urban growth, heat risk, and governance challenges in Freetown

Freetown, the capital of Sierra Leone, has experienced rapid population growth, expanding nearly fifty times over the past two generations. As the city has grown, large areas of forest have been replaced by urban development. This loss of tree cover has intensified climate risks, particularly extreme heat, contributing to heat-related illnesses, increased mortality, and productivity losses.

Freetown's reaction - the Heat Action Plan - showcases how collaborating across different governance levels is an important step make cities more resilient to climate change.

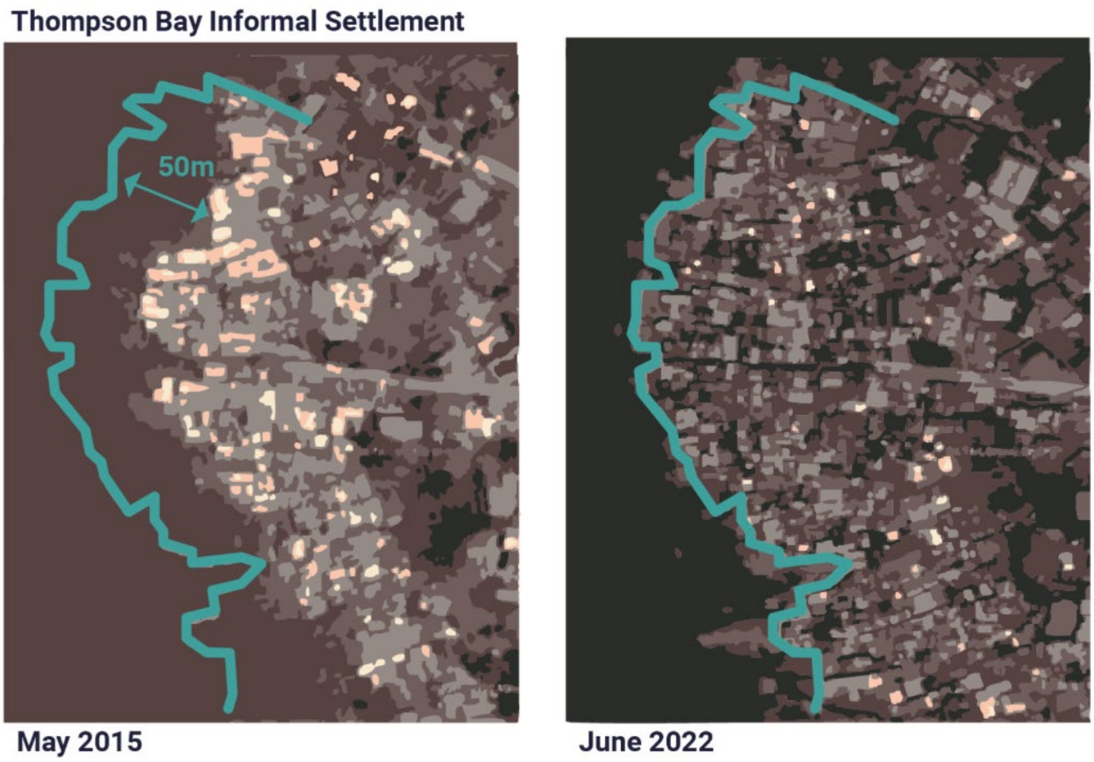


Figure 18. Informal Settlement Development in Thompson Bay, (C) Eugenia Kargbo

The Heat Action Plan: Coordinating governance for urban resilience

In response to rising heat risks, the City of Freetown's developed a **Heat Action Plan**, demonstrating how collaboration across governance levels is essential for building urban resilience. The plan focuses on three main objectives:

- Engaging Freetown's population to raise awareness of heat risks and possible solutions, while coordinating the city's many partners and agencies to work together effectively.
- Building equitable and sustainable heat adaptation measures, with a strong focus on protecting the most vulnerable groups while strengthening long-term urban resilience.
- Mobilising finance and partnerships to ensure that governance arrangements translate into effective action on the ground.

This approach shows how governance is not only about setting policies, but also about aligning institutions, resources, and actors to implement them.

An example of governance and finance in action: #FreetownTheTreeTown

One concrete initiative that supports Freetown's broader heat and climate strategy is **#FreetownTheTreeTown**. The initiative aims to **plant, grow, and digitally track five million trees** and restore 5,000 hectares of land by 2030. These efforts contribute to sequestering approximately 100,000 tons of carbon dioxide, while also reducing environmental risks such as extreme heat, flooding, and landslides.

The initiative follows a data-driven approach to urban reforestation. Through tree tracking, verification, tokenisation, and impact investment, the initiative ensures that each planted tree contributes measurably to climate resilience. Its success depends on a strong network of partners and financial backers, highlighting the importance of coordination, innovative financing, and shared responsibility in urban climate governance.

Let's Talk About Timing: The Disaster Risk Management Cycle

Disaster risk management is not only about what happens during a crisis. It also includes what cities do before disasters occur and after impacts happen, using lessons learned to reduce future risks. This timing is captured in the **disaster risk management cycle,** which links:

Preparedness: actions taken before a disaster to prepare for managing a potential crisis. For anticipated risks, this is often the main entry point.

Response: immediate actions taken during and right after a disaster to save lives and minimize urgent impacts.

Prevention: measures designed to reduce or avoid future disaster impacts, lowering risk before hazards turn into crises.

Recovery: efforts to restore services, livelihoods, and normal activities after a disaster, while strengthening resilience for the future.

Together, these phases show that effective disaster risk management is a continuous process, not a one-time action, and that decisions made before disasters are just as important as emergency response.

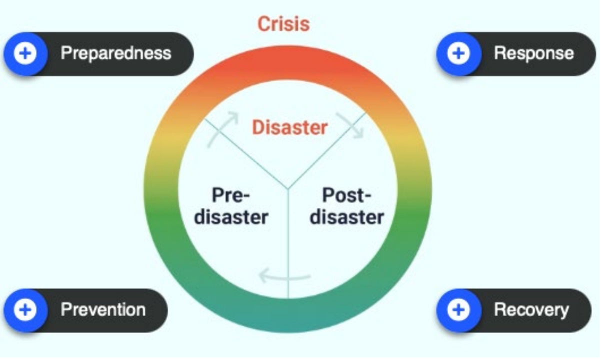


Figure 19. Disaster risk management cycle.

FINANCING

Case Study: Financing Risk-Informed Urban Development in Accra, Ghana

Accra's exposure to climate risk is shaped by its rapid urban growth and coastal location. As the city expands, increasing numbers of people settle in low-lying and informal areas along the coast and floodplains. **Coastal erosion, flooding, and poor sanitation** threaten homes, livelihoods, and basic services, particularly for low-income communities that have fewer resources to cope with these risks.

To address these challenges, the city is implementing the **Greater Accra Resilient and Integrated Development (GARID) Project**, which combines infrastructure upgrades with improved urban services. Key actions include increasing the capacity of the Odaw drainage channel, improving upstream floodwater detention, introducing a flood forecasting system, and strengthening solid waste collection in underserved neighbourhoods to reduce flood-related health and sanitation risks. Together, these measures aim to improve urban living conditions while reducing vulnerability to climate hazards.

Figure 20. Coastal exposure in Accra, where urban growth and shoreline erosion increase climate risks for communities.

Financing plays a central role in making these interventions possible. The GARID project is supported through a blended financing approach, including a loan from the World Bank, grant co-financing from the Green Climate Fund (GCF), and a concessional loan component. This mix of financial instruments allows the city to invest at scale while keeping long-term costs manageable.

Accra's experience shows that effective urban resilience depends on strong institutions, coordinated planning, and access to sustainable finance. When local authorities, communities, and international partners work together, climate resilience becomes part of how the city grows—helping ensure that development protects people rather than placing them at greater risk.

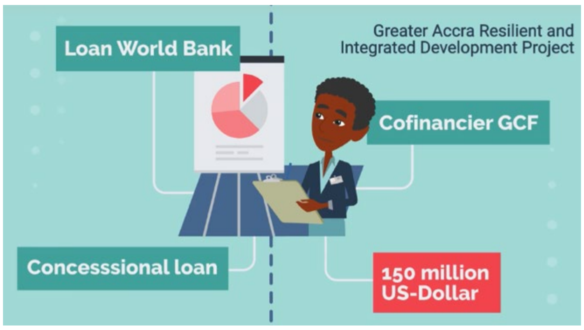


Figure 21. Blended financing structure of the GARID Project.

Financing Risk-Informed Urban Development

As we have seen in the examples, strong and diversified financing is essential for managing climate risks and turning plans into action. Cities rarely rely on a single source of funding; instead, they combine different financial instruments to support preparedness, prevention, response, and recovery.

Urban risk management can be financed through several main sources:

Public funds: these include national disaster and environmental relief funds, as well as instruments such as green bonds, which help channel public resources toward climate-resilient investments.

Municipal budgets: cities can allocate their own revenues—such as taxes, fees, and service charges—to finance local risk reduction measures and resilience projects.

Other sources: international support plays an important role, including grants, concessional loans, and philanthropic funding provided by development banks and humanitarian organizations.

Private investments and blended finance: risk reduction can also be supported through local businesses, investors, and public–private partnerships, often combining public and private resources to share risks and mobilize larger investments.

Together, these financing sources enable cities to move from risk awareness to concrete action, ensuring that resilience measures are not only planned but sustainably funded.

Investing City Resources for Disaster Risk Reduction

Once funding is secured, the next challenge is **how cities invest their resources** to reduce risk and protect people from disasters. Effective investment focuses on both immediate needs and long-term resilience, ensuring that resources reach where they are most needed.

Identifying vulnerabilities is the first step. Understanding where risks are highest helps cities direct funds wisely. This requires data-driven analysis combined with community engagement to capture different perspectives and avoid leaving vulnerable groups behind.

Strengthening core infrastructure is essential to protect vital city assets such as roads, hospitals, and schools. Investing in resilient and smart infrastructure helps cities withstand disasters and recover more quickly after emergencies.

Building community strength plays a critical role across all phases of disaster risk management. Resilience grows when communities are empowered, local networks are supported, and neighbours can rely on one another before, during, and after disasters.

Emergency coordination ensures that when disasters occur, responses are fast and effective. Prepared teams, clear responsibilities, and strong coordination mechanisms are key to saving lives and minimizing impacts.

Rapid recovery and social support help families and communities rebuild quickly after disasters. Timely support strengthens social cohesion and reduces long-term consequences.

Finally, **building long-term capacity** through collaboration between city leaders, businesses, and communities creates lasting resilience and prepares cities to face future challenges.

Key Takeaways: Governance and Financing of Risk-Informed Urban Development

Urban resilience does not depend only on understanding risks, but on **how cities organise decisions, coordinate actors, and mobilise resources** to act on those risks. Governance and financing shape who is protected, when action is taken, and how effective responses can be over time.

Key takeaways from this module include:

- In every city, lots of different groups help make decisions to keep people safe. **Every actor has a role** – managing risks takes everyone.
- Inclusive urban risk governance is very important to consider the **interests, concerns, and needs** of all actors and the population in the city.
- **Each group experiences risks differently**, so listening to all voices helps create better and fairer solutions.
- The disaster risk management cycle includes **prevention, preparedness, response, and recovery.**
- **Strong financing is key** to managing climate risks. Cities need **clear budgets and accessible funds** to prepare for disasters, respond effectively, and recover.

Module 4 – Prevention and Preparedness

Purpose of this Module

This module focuses on **prevention and preparedness** as key components of urban disaster risk management. It explores how cities can anticipate risks, reduce impacts before disasters occur, and strengthen their capacity to respond through early warning systems. The module highlights why timely information, clear communication, and inclusive systems are essential to protect lives and livelihoods—especially in rapidly growing urban contexts.

Why Prevention and Preparedness Matter

Cities face very different risks, shaped by their geography, infrastructure, and patterns of development. In Cairo, for example, the Nile is a vital source of water and life for millions of people—but it can also become a source of risk when water quality deteriorates or pollution increases.

Figure 22. Urban communities along the Nile face everyday exposure to water-related risks.

In Cairo, not all communities receive the same information or level of protection. While pollution may be monitored near hotels or high-value areas, residents in informal or underserved neighbourhoods often rely on visible signs—such as changes in colour or smell—as their only form of warning. This shows that risk is not only about the hazard itself, but also about **who receives information, when, and through which channels.**

Prevention and preparedness aim to address this gap. By identifying risks early, monitoring key indicators, and ensuring that information reaches everyone in time, cities can reduce harm before disasters escalate. This applies not only to floods and storms, but also to less visible risks such as water contamination, heatwaves, or low water levels.

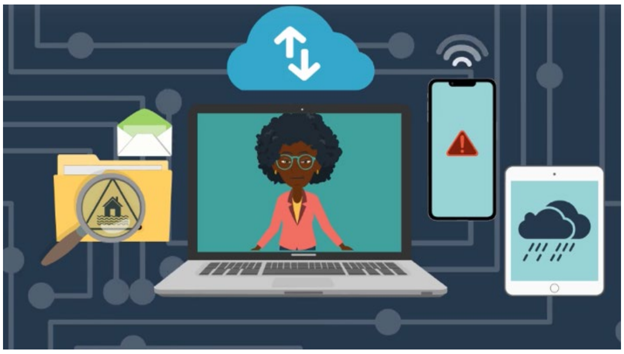


Figure 23. Early warning systems help monitor risks and share timely information.

By the end of this module, you will have a clear understanding of what early warning systems are and how they work, the types of urban risks they are designed to address, and the key requirements for setting up effective early warning systems in a local urban context. This knowledge will help you see how timely information and preparedness can reduce risks and protect urban populations before hazards turn into disasters.

Early Warning Systems in Cities and Urban Areas

An **early warning system (EWS)** helps people, communities, and local authorities react quickly when danger is near. While they are often associated with storms or flooding, early warning systems are also essential for heatwaves, droughts, pollution, or low water levels. By combining monitoring data, risk information, and clear communication, EWS aim to ensure that warnings reach people in time to act.

Early warning systems are especially important in cities, where risks can escalate quickly and impacts are unevenly distributed. **Short-term action saves lives:** timely alerts allow fast, lifesaving responses in the critical moments before a disaster occurs. At the same time, EWS contribute to **long-term resilience** by supporting adaptation to climate change, helping cities adjust practices and reduce vulnerability to increasingly frequent hazards.

Early warning systems also play a key role in **empowering communities with knowledge**. Accurate weather and climate forecasts, when communicated clearly, help people understand changing risks and make informed decisions—both for immediate response and for longer-term coping strategies. This is particularly important in urban areas where not all communities receive the same level of information or protection.

Overall, effective early warning systems depend not only on technology, but also on inclusive communication, trust, and the ability to reach all groups within a city. When warnings move faster than harm, cities are better prepared to prevent disasters from becoming crises.

The Four Pillars of an Early Warning System

A strong early warning system is built on **four interconnected pillars**, all of which are equally important for reducing the social, economic, and environmental impacts of extreme events. If one pillar is weak or missing, warnings may not lead to timely or effective action.

1) **Hazard Monitoring, Detection, and Forecasting**

Early warning systems rely on reliable tools and technology to monitor multiple hazards, detect early signals, and forecast potential impacts. Continuous observation and analysis make it possible to anticipate what might happen, allowing communities and authorities to act before it is too late.

2) **Risk Knowledge**

Effective early warning requires a clear understanding of who and what is exposed, vulnerable, and at risk. This includes mapping and assessing disaster risks to identify the hazards a community faces, which groups are most vulnerable, and what resources are available to respond. Strong risk knowledge ensures that warnings are relevant and targeted.

3) **Dissemination and Communication of Warnings**

Warnings and risk information must quickly reach everyone who needs to act, including people living in remote or vulnerable areas. This requires clear and consistent messages, as well as strong coordination between institutions, so that information is trusted, understood, and acted upon.

4) **Preparedness and Response Capability**

Warnings only save lives if they lead to action. Preparedness and response capacity ensure that people and institutions know how to respond promptly and effectively when a warning is issued. This includes regular training, drills, and education to turn information into timely and coordinated response.

Technologies for Early Warning Systems

Early Warning Systems rely on different technologies to detect hazards early, monitor changes, and transmit alerts in time so people and authorities can act.

- **Weather stations** monitor atmospheric conditions to detect and anticipate extreme weather events before storms occur.
- **Tsunami early warning systems** measure sound waves and water levels using hydrophones to detect abnormal sea movements.
- **Seismic monitoring equipment** detects minor shockwaves that can indicate the onset of earthquakes.
- **Telecommunication towers and antennas** transmit data and warnings from sensors to authorities and communities, ensuring alerts reach people quickly.

Together, these technologies support timely warnings and help transform risk information into early action.

Community participation in early warning systems

Communities play a central role in identifying risks and managing them effectively. When people are actively involved, risk information becomes more accurate, trusted, and actionable.

Early warning systems work best when they are **community-driven and co-produced**, bringing together different actors to contribute at each stage of the process. This includes identifying key actors and building partnerships, sharing information to create common understanding, exploring local needs, and jointly developing solutions.

Through collaboration, communities and institutions can **co-deliver solutions**, strengthen local capacities, and empower people to act on warnings. These elements reinforce one another, helping early warning systems become more inclusive, effective, and sustainable over time.

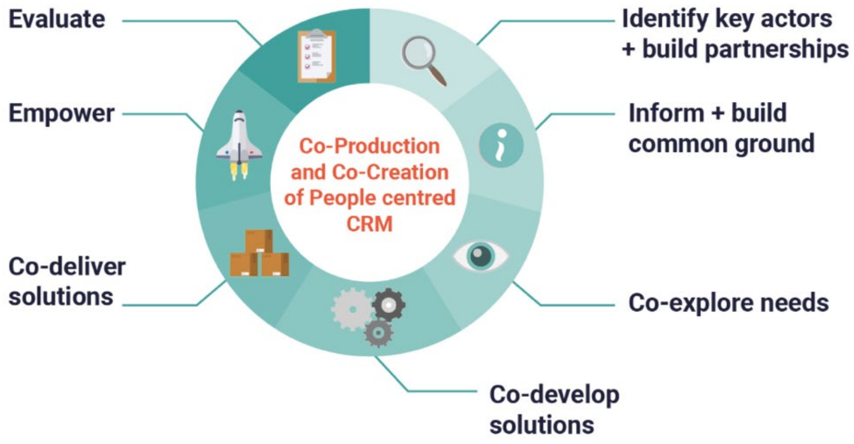


Figure 24. Schematic of community collaboration elements.

Determining Risks for Early Warning Sensors

Risk assessment helps cities decide which hazards require early warning systems and where sensors should be placed. By understanding both the likelihood of an event and its potential impact, cities can prioritize risks and allocate resources more effectively.

Each city should define clear risk thresholds to determine when alerts are triggered and when a situation is considered a disaster. This is especially important because even smaller or short-term events, if they occur frequently, can have a serious cumulative impact over time.

A common tool to support this process is the **likelihood–impact matrix,** which helps guide decisions on when to issue warnings, plan responses, and focus preparedness efforts—particularly for risks that are both frequent and potentially severe.

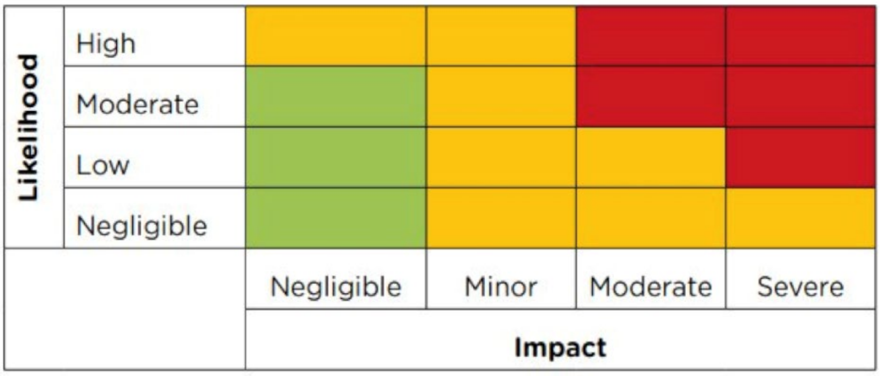


Figure 25. Matrix for risk determination, by WHO, (C) EC-OIE

Keep in mind: Risk thresholds are highly context-specific. For example, a heatwave alert may be triggered at 30°C in one city, while in another city with a different climate it may be activated at 25°C. What matters is how local conditions, exposure, and vulnerability shape risk.

Case Study: Early Warning for Water Pollution in Cairo, Egypt

The Nile runs through the heart of Cairo and is essential to daily life for millions of people. At the same time, it carries waste from farms, factories, and households, creating serious but often invisible risks for communities living along its banks. For many residents, pollution only becomes evident when the water changes colour or smell—often too late to prevent harm.

To address this challenge, the city has established a **water quality monitoring network** along the Nile and its canals across Greater Cairo. Sensors installed in the river measure key indicators such as temperature, pH, chemical concentrations, and water levels on an hourly basis. When readings exceed safe thresholds, the system automatically triggers alerts at the environmental control centre, allowing authorities to detect pollution early rather than relying on visible signs alone.

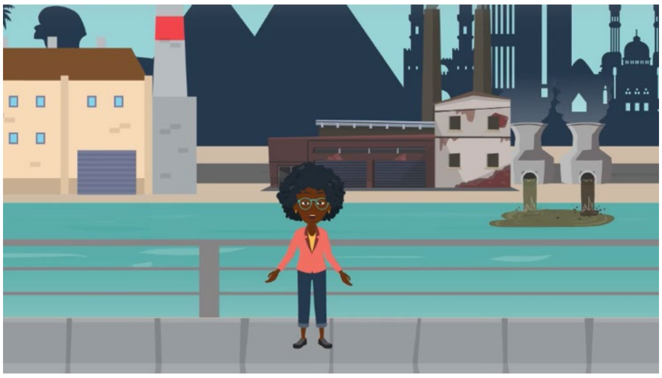


Figure 26. Monitoring pollution risks along the Nile in urban Cairo.

Once an alert is generated, sensor data is cross-checked with laboratory samples to confirm contamination. If pollution is verified, warnings are sent to local councils, health authorities, and water utilities, enabling rapid action. These actors can close affected water intakes, issue public health advice, or restrict water use to reduce exposure and prevent further impacts.

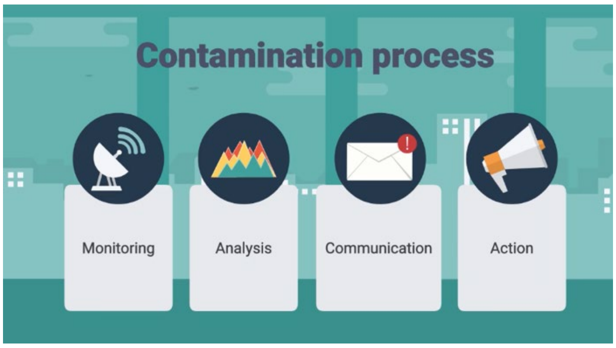


Figure 27. From monitoring to action: the early warning process for water contamination.

Ensuring that warnings reach everyone is a key part of the system. In addition to digital alerts, the city works with local councils, mosques, radio, and loudspeaker announcements to communicate risks to communities with limited internet access or smartphone use. The objective is clear: no one should drink, bathe, or use unsafe water simply because they did not receive a warning.

In Cairo, early warning systems go beyond forecasting floods. They play a critical role in **detecting hidden environmental risks**, linking scientific monitoring with governance structures and community action, and ensuring that timely information—rather than accidents—guides how people live with their river.

Systems analysis for the operationalisation of early warning systems

Effective early warning systems rely on inclusive governance of data and decision-making. This means combining vertical and horizontal coordination, as well as bottom-up participation, to ensure that information flows efficiently from monitoring to action.

Depending on the type of hazard, locally driven early warning data and decision-making can support diverse roles and faster dissemination, helping alerts reach communities in ways that are timely, trusted, and actionable.

People-centred systems analysis in practice

Systems analysis becomes most effective when it actively involves communities. In the Developing Risk Awareness through Joint Action (DARAJA) programme, implemented in cities such as Dar es Salam, women in informal settlements take part in collecting weather station readings and work closely with meteorological experts. The information is verified and shared back, allowing communities to understand flood risks and act early.

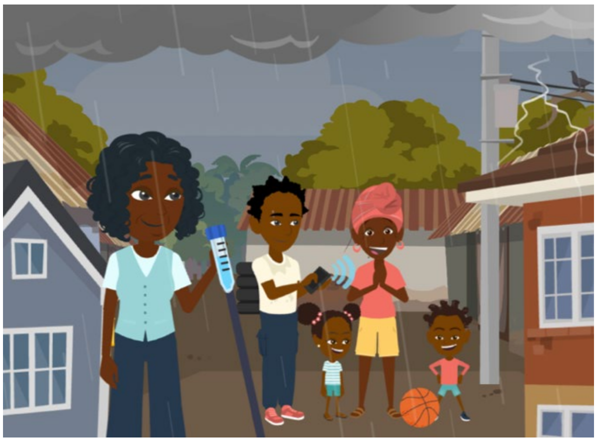


Figure 28. Community members collecting, interpreting, and sharing weather information.

This approach shows how people-centred systems analysis strengthens early warning systems by linking local knowledge, technical expertise, and clear communication—ensuring warnings are not only generated but understood and used.

Key Investment Areas for Effective Early Warning Systems

An effective Early Warning System (EWS) investment plan focuses on strengthening several key, interconnected areas that work together to save lives and reduce disaster impacts. Investing across these areas—and estimating their costs—helps strengthen urban risk governance and build long-term resilience.

Key investment areas include:

- Institutional and policy strengthening, to ensure clear mandates and coordination.
- Observation networks, including meteorological and hydrological monitoring.
- IT infrastructure to support data collection, storage, and processing.
- Integrated data centers that connect information across agencies.
- Forecast and modeling services to anticipate hazards and impacts.
- Hazard and risk assessment to identify priorities and thresholds.
- Impact-based forecasting to translate data into actionable warnings.
- Risk communication and dissemination systems to reach all populations.
- Community capacity building to support preparedness and local action.

Early Warning Infrastructure

Early warning infrastructure develops over time and requires phased investment. Cities can think about EWS development across short-term actions, short- to medium-term investments, and future system status.

Short-term

In the short term, cities should:

- Maintain an up-to-date citywide hazard, exposure and vulnerability assessment and a hazards hotspot register.
- Ensure GIS and remote sensing infrastructure is available to support a geodatabase.

These actions provide the basic information needed to decide where sensors and monitoring systems are most urgently required.

Short- to medium-term investment areas

Over the short to medium term, cities should focus on strengthening coordination and data systems by:

- Having an informal EWS city or city-regional Task Force that facilitates coordination in earth data observation among agencies and install minimum weather and hydrological observation system.

- Constructing an agency-level spatial data infrastructure formulated for hazards.
- Ensuring that small maintenance budgets for hydrometeorological stations are included in department operating budgets.
- Clarifying institutional mandates on setting up of observation stations and data collection.

Future status under a short-term scenario

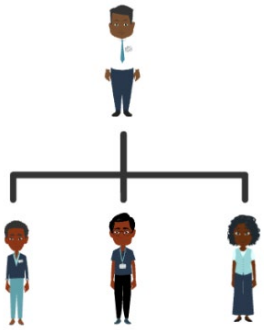
Looking ahead, cities can further strengthen EWS dissemination and reach by:

- Investing in crowd sourced system like mobile phone, social media for dissemination network EWS services.
- Engaging private sector to warning dissemination and public alert services.

Protocols for Emergency Coordination

Effective emergency coordination relies on **clear structures, defined responsibilities, operational capacity, and secured funding**. Together, these elements ensure that warnings can be translated into timely and coordinated action during a disaster.

A key first step is to **establish a disaster coordination centre**, equipped with the necessary tools, infrastructure, and communication systems. In many contexts, this centre operates alongside a national coordination centre, making strong vertical linkages essential to ensure information flows smoothly across levels of government.



Clear **command and leadership structures** are equally important. Responsibilities should be assigned to a designated **lead commander** of the emergency coordination centre, with the authority to make critical decisions, including declaring the start and end of a disaster response.

Operational capacity on the ground must also be ensured. Where feasible, field-level emergency response units should be established and properly equipped. This includes planning for rescue operations, evacuation routes, and emergency equipment, with services such as the fire department playing a central role in response efforts.

Finally, emergency coordination requires **sustainable financing**. Budgets for emergency coordination activities should be fully integrated into the city's annual budget, ensuring that preparedness and response capacities are not dependent on ad hoc or emergency-only funding.

Development of an Emergency Response Plan

Early warning systems are only effective if communities also know how to react once a warning is issued—what actions to take, where to go, and who is responsible. An emergency response plan helps translate warnings into timely and coordinated action, reducing harm and confusion during crises.

To build such a plan, cities can think in terms of short-term, medium-term, and future scenarios, each focusing on progressively strengthening coordination, communication, and institutional capacity.

Short-term scenario

- Establish an Emergency coordination Task Force.
- An improved mobile phone dissemination network for hydrometeorological services.
- Engage private sector to warning dissemination and public alert services.

Medium-term scenario

- Develop protocol for disasters declaration, how communicated and a response team.
- Build ministry capacity for analysing and disseminating data and information to their respective sectoral users.
- Improve radio, television and mobile phone dissemination capability.

Future status

- Develop an agreed impact-based response system with stakeholders and the broader community.
- Maintain and develop the platform for providers and users of the hydrometeorological services.
- Partner with development agencies to develop public awareness and outreach materials.
- Develop protocols and Standard Operating Procedures (SOPs) during emergency situations.
- Arrange communication campaigns & training of local leaders.

Behavioural, Communication and Information in Early Warning Systems

Effective early warning systems rely not only on technology, but also on how people receive, share, and act on information. Communication, behaviour, and information flows determine whether warnings are understood and lead to timely action. Crowdsourcing and crowdsensing are complementary tools that strengthen early warning systems by directly involving the public in monitoring risks, sharing information, and supporting decision-making:

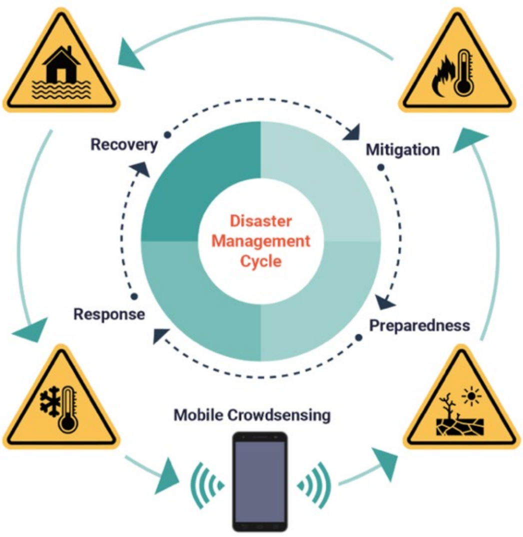


Figure 29. Disaster Management Cycle

Crowdsourcing uses public participation to help solve problems and support decisions before, during, and after an event. Examples include reporting blocked roads, translating shelter information, mapping safe routes, or helping prioritize relief needs.

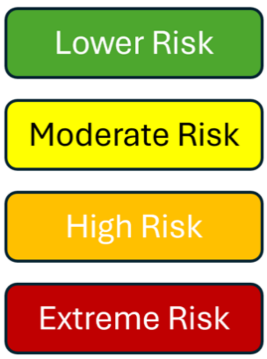
Crowdsensing uses data collected passively or semi-automatically from people's devices and simple sensors—such as GPS, accelerometers, air or water quality probes—to measure real-time conditions. This can include detecting shaking patterns, flood depths, air-quality spikes, or heat hotspots, helping authorities trigger early warnings and responses more quickly.

Together, these approaches enhance communication, expand data coverage, and help ensure that early warning systems are people-centred, responsive, and inclusive, especially in rapidly changing urban environments.

Risk communication

Risk communication is essential to ensure that warnings are clear, easy to understand, and actionable. Simple systems such as traffic lights and sirens can be used to alert the population quickly.

Risk messages can also be coded by color, moving from low to high risk, to help people easily recognize the level of danger and respond appropriately.



Dissemination, linkage with mobile telephone providers, SMS, and social media

Effective early warning systems depend on strong dissemination channels that ensure warnings reach people quickly, clearly, and through platforms they already use. Linking early warning systems with mobile providers, SMS services, and social media helps translate risk information into timely and actionable messages for different groups and contexts.

Short term scenario:

- Develop awareness materials and campaign to enhance risk communication.
- Create a platform for providers and users of the EWS services.
- Develop protocols and Standard Operating Procedures (SOPs).
- Engage actors like universities CSOs, Government ministries, Local NGOs, Schools.

Medium-term to Future scenarios:

- Develop an integrated impact-based response system with stakeholders and the broader community with dissemination tools.
- Identify and code safe areas for evacuation and guides to such areas.

Budgeting for EWS investment

Early warning system investments vary significantly in cost, depending on the type of infrastructure, coordination, and technology involved. Some components can be implemented with relatively limited resources, while others require substantial long-term financial commitments.

At the **lower end of the investment** spectrum are forecast and modelling services, which often build on existing data and technical capacity to improve risk analysis and decision-making.

A **moderate level of investment** is needed for institutional and policy enhancement, integrated data centers, hazard assessment, impact-based forecast plans, and community capacity enhancement, as well as for IT systems and risk communication and dissemination systems. These elements focus on strengthening coordination, data management, communication channels, and human capacity so that early warnings are credible, well-managed, and effectively shared with the population.

At the **highest end of the investment** scale are observation networks, such as hydrometeorological stations, sensors, and monitoring equipment.

Understanding these different investment levels helps cities prioritize actions, sequence investments over time, and design early warning systems that are both effective and financially realistic.

Key Takeaways: Prevention and preparedness

This module brings together the main concepts of **prevention and preparedness**, showing how early warning systems help cities anticipate risks, communicate clearly, and act in time. The points below summarise how effective EWS function in practice and why they are essential for reducing disaster impacts in urban contexts.

- Early Warning Systems follow four steps: **monitoring, risk knowledge, warning, and response.**
- They are **multi-hazard**, helping Cairo manage both pollution spikes and drought/low-flow with heat.
- Impact-based thresholds turn sensor data into clear **“do this now” instructions**.
- Alerts should use **simple language, icons, and multiple channels** like SMS, radio, loudspeakers, and WhatsApp.
- **Practised roles and first two-hour actions** ensure warnings quickly turn into **real action.**

Module 5: Water resilience in Cities

Purpose of this Module

This module introduces the concept of **water resilience in cities** and explains why it is increasingly important in African urban contexts as climate pressures, rapid urban growth, and rising demand place greater strain on water systems. It explores how water risks are shaped by the interaction between climate variability, urban development, infrastructure, and resource availability, and examines the strategies cities can use to strengthen resilience. By the end of the module, learners will understand how water systems function in urban areas, appreciate the main risks affecting them, and gain a clearer understanding of the processes and requirements involved in building water resilience in cities through practical actions.

Water Risks in African Cities

Across Africa, **water availability is declining** in many regions, while water-related risks are becoming more severe. Some cities face dangerous flash floods or rising sea levels, while others must cope with extremely limited rainfall, increasing demand, and fragile water reserves. These pressures are particularly visible in dry urban environments, where low reservoir levels, variable rainfall, and limited natural water availability place constant stress on urban systems.

Figure 30. Wayer scarcity and urban water supply challenges in Windhoek.

In water-scarce cities such as Windhoek, these challenges are intensified by the interaction between climate and urban growth. Drought does not only affect water supply; it also has wider consequences for **food security, livelihoods, and social stability.** As population growth and economic expansion continue, demand for water can rise faster than supply. By mid-century, water needs in such cities are expected to increase sharply, showing how quickly urban development can deepen water stress where resilience measures are not in place.

Water resilience therefore requires more than simply expanding supply. It depends on how cities plan, manage, and protect their water systems in the face of uncertainty. Understanding what happens when water limits meet urban growth helps clarify why resilient water systems are essential for safer and more sustainable cities.

Urban Water Pressure in African Cities

Urban water demand in Africa is projected to grow at **three times the global average**, driven by rapid demographic expansion, industrialisation, and rising living standards. At the same time, the infrastructure supplying African cities is already under severe strain. Many utilities across the continent face persistent service deficits, high levels of **non-revenue water**, and limited wastewater treatment capacity. As a result, demand for water is increasing much faster than the systems designed to supply it.

Non-revenue water refers to water that has been produced or pumped but is lost before it reaches the consumer, often due to leaks, illegal connections, or metering inaccuracies. These losses significantly reduce the efficiency of urban water systems and increase pressure on already limited water resources.

A System Under Stress

Across Sub-Saharan Africa, water systems are already struggling to meet the needs of rapidly growing urban populations. Currently, only **27 percent** of urban residents have access to safely managed drinking water services (WHO, 2021). At the same time, water utilities frequently lose between **30 and 50 percent** of their water supply before it reaches consumers (African Development Bank, United Nations Economic Commission for Africa, & African Union, 2000).

These losses reflect ageing infrastructure, inadequate maintenance, and systemic inefficiencies in many urban water networks. Without urgent investment and institutional reform, continued urban growth combined with climate pressures is likely to widen the gap between water demand and reliable supply. This gap can increase inequality in access to water services and heighten vulnerability to both water scarcity and water-related risks in cities.

Climate Change Is Reshaping Urban Water Risk

Before exploring solutions, it is important to understand how climate change is transforming the water challenges that African cities already face. These pressures are not only future risks; **they are already occurring today and are expected to intensify in the coming decades**. Climate change is therefore reshaping the way water risks emerge and interact within urban environments.

Climate change is affecting water systems across African cities in multiple ways. These impacts interact with existing pressures such as rapid urban growth, infrastructure limitations, and unequal access to services. As a result, climate change acts as a **driver that intensifies existing water risks and vulnerabilities**.

Several key climate-related processes are already influencing water systems in cities:

Rainfall Variability: Rainfall patterns are becoming increasingly unpredictable across African cities. Prolonged droughts reduce water availability, while more frequent and intense floods can overwhelm drainage and supply systems. This cycle leaves utilities with less time to recover between extreme events and increases pressure on already fragile infrastructure.

Coastal Exposure: Coastal cities are increasingly exposed to sea-level rise, coastal erosion, and saline intrusion into groundwater. As saltwater contaminates freshwater reserves, safe drinking water becomes harder and more expensive to secure, placing additional pressure on already limited urban water supplies.

Chronic Water Scarcity: Arid and semi-arid cities face long-term water scarcity driven by declining aquifer recharge and growing competition for limited water resources. At the same time, rapid urban expansion is accelerating demand just as natural replenishment of water sources is slowing.

Higher temperatures/ heat waves: Speed up evaporation from rivers, lakes and soil and green spaces dry out faster. Hot climate conditions + low water levels can also concentrate pollutants and produce water quality problems.

Climate as a Threat Multiplier: Climate change does not act in isolation. Instead, it magnifies existing vulnerabilities within urban systems. Weak infrastructure, rapid urban growth, and inequality interact with climate pressures to widen water access gaps, increasing both social and economic risks in cities.

Understanding Water Resilience

Water resilience refers to strengthening **water systems** so that they remain secure under climate stress and less vulnerable to water-related hazards such as droughts, floods, or sea-level rise.

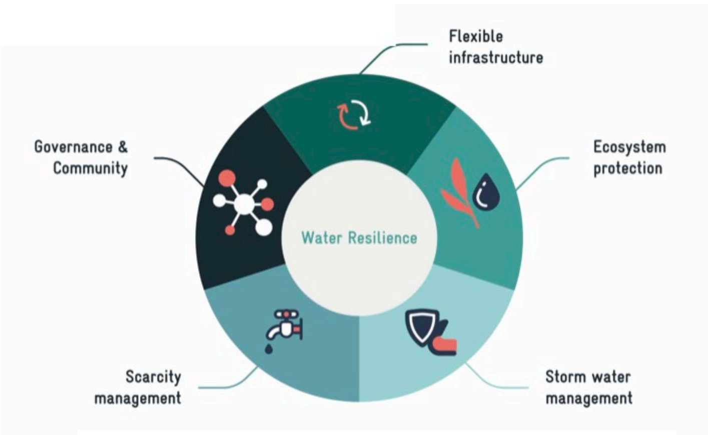


Figure 31. Key building blocks of urban water resilience.

Water resilience **is multi-dimensional**. It includes making water systems more flexible and adaptive while protecting and using natural ecosystems in ways that improve both water supply and quality. Together, these elements help cities cope with uncertainty and protect long-term water security.

Water Systems – Where Does the Water Come From?

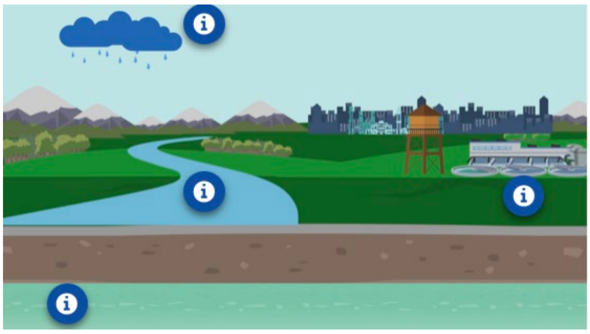


Figure 32. Components of an urban water system linking natural resources and infrastructure.

Urban water systems connect **natural water sources** with **human infrastructure** that captures, treats, stores, and distributes water to cities. Understanding these interconnected components is essential for building resilient water systems capable of adapting to climate pressures and growing demand.

Urban water systems depend on several interconnected sources and infrastructures that regulate water availability and supply. The main components are:

1. **Atmospheric and Frozen Water**

This part of the system includes atmospheric water such as rainfall, mist, snow, and fog, as well as frozen water stored in mountain ice and seasonal snow. These sources regulate river flow and recharge water systems over time, making them critical for long-term supply.

2. **Surface Water Systems**

Surface water includes rivers, streams, lakes, and reservoirs. These are the most visible water sources for cities and agriculture, but they are highly sensitive to climate variability, pollution, and overuse.

3. **Groundwater and Green Water**

Groundwater stored in aquifers and green water held in vegetation form hidden but essential reserves. They support ecosystems, agriculture, and urban supply, especially during droughts when surface water declines.

4. **Urban Water Infrastructure**

Urban water infrastructure includes reservoirs, treatment plants, and distribution systems that capture, store, treat, and deliver water to cities. Their resilience determines whether natural resources can reliably reach communities.

How Urban Water Systems Work

Before discussing resilience, it is important to understand **how cities actually get their water.** Urban areas draw water from both natural sources—such as groundwater, rivers, lakes, and wetlands—and engineered infrastructure, including reservoirs, dams, and storage systems. These sources are often located far beyond the city boundary, which means urban water management depends on a much larger connected landscape.

To build resilience, cities must plan for and monitor all possible water resources linked to the urban system. Understanding where water comes from is just as important as managing how it is used. Urban water infrastructure is designed to **abstract, store, treat, and distribute water safely** to people. Distribution networks—including storage tanks, pumping stations, and pressure control systems—ensure water can reliably reach homes, businesses, and public services across the city.

The Cycle of Building Urban Water Resilience

Cities become resilient when they actively manage their water systems through **planning, inclusion, design, and long-term investment**. Water resilience is not linear; rather, it is a cycle of actions that reinforce one another.

Planning for water means integrating water into urban planning and decision-making. This includes managing land use, protecting watersheds, diversifying supply sources, and investing in infrastructure that reduces flooding impacts. Planning helps cities prepare for uncertainty instead of reacting only when crises occur.

Prioritising vulnerable communities is essential if water resilience is to reduce inequality. Policies should expand safe access to water and sanitation for the most exposed populations, improve affordability, and include local knowledge in decision-making. A system is only resilient if it protects those most at risk.

Designing solutions at scale means moving beyond isolated projects. Resilient design includes upgrading infrastructure, integrating nature-based solutions, and strengthening institutions so that innovations can be applied across entire urban water systems.

Investing for the long term is necessary to sustain resilience. Governments and partners need to align investments with long-term water security while ensuring maintenance, transparency, and equitable access. Without continuous funding, resilience efforts weaken over time.

Key Stressors on Urban Water Systems

Urban water vulnerability is shaped by interacting demographic, environmental, infrastructure, and governance pressures. These factors influence both water availability and the ability of cities to provide reliable and equitable water services.

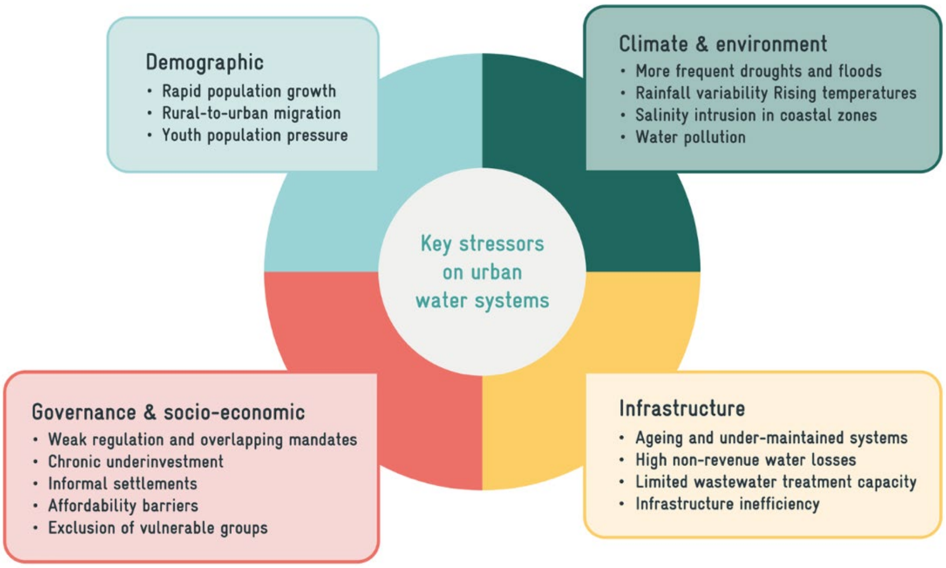


Figure 33. Key stressors affecting urban water systems.

Key implications

Demographic: rising demand for urban water services.

Climate and environment: reduced availability and increased flood risk.

Infrastructure: service interruptions and public health risks.

Governance and socio-economic factors: inequitable access and long-term system fragility.

Addressing Water Scarcity, Flooding, and Sea-Level Rise in Cities

Cities today face **different water risks at the same time**. Some struggle with water scarcity, others experience flooding, and many coastal cities must prepare for rising seas.

Cities become resilient when they actively manage these challenges through **planning, inclusion, design, and long-**

Figure 34. Urban water systems facing multiple climate-related risks.

term investment. Water resilience is not linear—it is a cycle of actions that reinforce each other.

The following section explores how cities can act to **reduce water shortages, manage floods, and adapt to sea-level rise**, strengthening urban water resilience over time.

Addressing Water Scarcity in Cities

Water scarcity is a growing challenge in many urban areas. Cities can strengthen resilience by combining demand management, efficiency improvements, water reuse, and protection of natural water systems. The following approaches illustrate key strategies that cities can implement.

Figure 35. Water scarcity affecting communities and urban water supply.

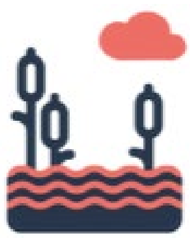
Manage demand. Cities can reduce water use through behavioural change campaigns and clear public information, supported by tools such as smart meters, household notifications, and public dashboards. Well-designed tariffs and "wise-use" block pricing can also reduce excessive consumption while protecting basic needs.

Improve efficiency and reduce losses. A major share of urban water never reaches users. Engineering improvements—such as leak detection, rapid repairs, pressure management, and better maintenance—can reduce wasted water and increase reliability without needing new sources.

Reuse and recycle water. Treated wastewater can be reused for non-drinking purposes such as irrigation, industry, or energy-related uses. Water reuse reduces pressure on freshwater resources and, in some contexts, can generate revenue streams that help fund system upgrades.

Increase storage and protect groundwater. Cities can harvest rainwater and stormwater locally or through centralised systems. They can also increase long-term security through managed aquifer recharge, for example using infiltration ponds or injection wells. Regulations are needed to prevent unsustainable groundwater extraction.

Protect watersheds and improve water quality. Land-use planning and pollution control help protect the catchments that supply urban water systems. Nature-based solutions, such as restoring wetlands or managing vegetation in catchment areas, can improve water retention and water quality.



Desalination (where appropriate). Desalination and advanced purification technologies can expand water supply using seawater or brackish water. However, these solutions are typically energy-intensive and costly, so they require careful feasibility assessment and strong water-quality monitoring.

Addressing Flood Risk in Cities

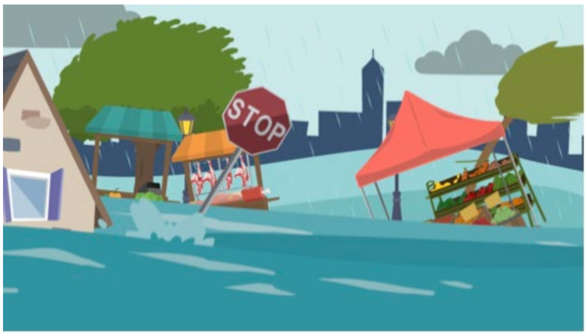


Figure 36. Urban flooding affecting streets, buildings and local markets.

Floods are becoming more frequent in many cities. Urban areas therefore need different strategies to reduce flood risk and protect communities. Effective flood management combines risk assessment, resilient infrastructure, planning regulations, and cooperation across urban and regional systems.

Strategies to Address Flood Risk

Cities can strengthen flood resilience through a combination of risk assessment, infrastructure improvements, planning measures, and coordinated water management.

Assess and prepare. Cities must first understand their flood risk. This includes mapping past flood events, identifying vulnerable areas and critical infrastructure, and modelling future climate impacts. Emergency protocols and early warning systems allow coordinated action and faster response when floods occur.

Build grey–green infrastructure. Flood resilience often combines engineered drainage systems with nature-based solutions. Grey infrastructure includes culverts, detention basins, and stormwater networks. Green infrastructure includes wetlands, stream restoration, and urban greening that absorbs and slows excess water.

Plan safer urban development. Urban planning plays a key role in reducing flood exposure. Cities should avoid building on wetlands and floodplains whenever possible. Zoning rules and building standards can reduce flood risks, while buildings can incorporate resilience measures such as rainwater tanks, green roofs, elevated floor levels, and flood-resistant design.

Manage waste and regional water flows. Blocked drainage systems increase flood risk. Effective waste collection and management prevent debris from clogging waterways and drainage channels. Cities also need to cooperate with neighbouring regions to manage upstream water flows, including through wetland restoration and river management.

Addressing Sea-Level Rise in Cities

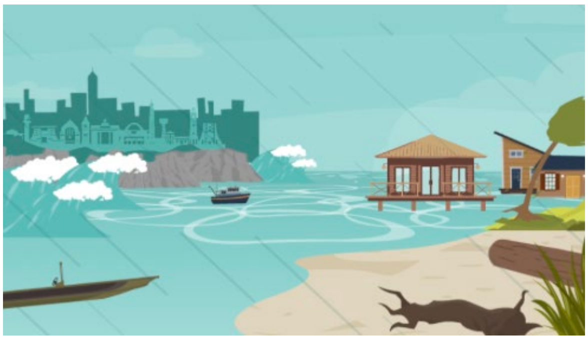


Figure 37. Coastal areas facing rising sea levels and increased flood risk.

Rising sea levels are increasing coastal flood risks in many cities. These are long-term challenges that require **strong coordination, planning, and governance**. Cities need a combination of ecosystem-based, structural, spatial, and social measures to reduce exposure and protect communities over time.

Strategies to Address Sea-Level Rise

Cities can respond to sea-level rise through a combination of ecosystem restoration, physical protection, urban adaptation, and long-term planning.

Restore coastal ecosystems. Wetlands and mangroves can reduce storm surges and coastal erosion naturally. Protecting these ecosystems lowers wave energy and provides affordable long-term protection. In this sense, nature protects coasts.

Build physical defences. Sea walls and flood barriers can hold back rising water. These measures can be effective, but they are also costly and tend to work best when combined with natural systems. In other words, engineering supports protection.

Adapt cities to water. Cities can reduce risk by restricting building in high-risk areas, elevating structures, and designing parks and public spaces that absorb floodwater. Here, the key idea is that design reduces risk.

Plan managed retreat. Some areas cannot be protected forever. In these cases, early planning for relocation can protect communities and avoid crisis-driven displacement. This highlights that retreat may be necessary in some contexts.

Case Study: Water Reuse and Drought Resilience in Windhoek, Namibia

Windhoek, the capital of Namibia, lies on an arid central plateau where rainfall is extremely limited and drought is a permanent feature of the climate. With no perennial rivers and minimal aquifer recharge, the city has long faced **chronic water scarcity**. As the city has grown, these pressures have intensified. Rapid population growth and expanding informal settlements have increased water demand, while repeated droughts have pushed reservoir levels dangerously low. Between 2013 and 2019, severe drought reduced reservoir levels to below 20 percent, affecting water security across the city. Low-income communities were particularly vulnerable, facing service interruptions, unsafe water, and rising costs.

Figure 38. Advanced treatment processes used for direct potable water reuse in Windhoek.

To address these challenges, Windhoek developed one of the world's most innovative approaches to urban water management. In 1968, the city became the **first in the world to pioneer direct potable reuse,** recycling treated wastewater into safe drinking water. Instead of relying only on distant reservoirs, the city invested in advanced treatment infrastructure capable of converting wastewater into high-quality drinking water. The Goreangab Direct Potable Reuse Plant uses a multi-barrier treatment system that meets World Health Organization standards and now supplies up to 30 percent of the city's water.

Water reuse was not the only strategy adopted. Windhoek also diversified its water supply through **managed aquifer recharge, rainwater harvesting, and groundwater rehabilitation**. By storing water underground during wetter periods and improving groundwater management, the city strengthened its ability to cope with prolonged droughts. These combined measures helped reduce dependence on a single water source and created a more resilient and diversified urban water system.

Financial governance also played a critical role. **Progressive tariff systems** were introduced to protect low-income households while discouraging excessive water use. Transparent financial management ensured that revenues were ring-fenced for infrastructure maintenance and system upgrades, preventing the diversion of resources and supporting long-term sustainability.

Institutional arrangements were equally important. Procurement contracts required strict safety and resilience standards, and the city partnered with private operators for technology transfer and plant management while maintaining strong **public oversight and accountability.** These governance mechanisms helped ensure that the system operated safely and reliably.

Figure 39. Public awareness campaigns encouraging water conservation in Windhoek.

Public engagement further strengthened the system. Awareness campaigns such as **"Save Water, Save Windhoek",** along with smart metering and school programmes, encouraged citizens to reduce water consumption and participate actively in water conservation. Over time, these efforts helped build public trust in water reuse and fostered a culture of responsible water use.

Today, Windhoek has maintained a **continuous water supply despite repeated droughts**, and its levels of non-revenue water are among the lowest in the region. After more than fifty years of operation, the city is widely recognised as a global model for urban water reuse and drought resilience. The experience of Windhoek demonstrates that even the driest cities can build lasting water resilience through innovation, strong governance, and long-term planning.

Strengthening Governance for Resilient Water Systems

Cities have many technical tools to manage water risks, but these tools only work when institutions are organised to support them. As earlier modules highlighted, infrastructure alone is not enough. Clear responsibilities, strong coordination across sectors, and the ability to **plan, finance, and regulate effectively** are essential for resilient water systems.

In many African cities, governance is still fragmented. Multiple ministries and agencies often share overlapping roles in water, sanitation, environment, risk management, and urban development, without a shared vision or accountability framework. This fragmentation can lead to duplication, inefficiency, and weakened public trust. Effective water governance therefore depends on four foundations: **harmonised mandates, strong institutional coordination, transparent performance-based management, and inclusive leadership** capable of driving long-term change.

Roadmap for Urban Water Resilience

Building water resilience does not happen overnight. Cities typically move through stages—from understanding risks, to planning solutions, to scaling what works. This roadmap outlines a practical pathway that cities can follow to strengthen resilient urban water systems over time.

Figure 40. Roadmap for urban water resilience, outlining key stages from diagnostics to monitoring and scale-up.

Actor Engagement for Resilient Water Systems

Water resilience depends on **coordinated action across different actors**, each with specific roles and responsibilities. Municipal authorities play a central role in cross-sector coordination and planning, while utility companies are responsible for operations and service delivery. Water resource departments help manage and protect water sources and oversee allocation.

At the same time, community organisations and NGOs contribute to preparedness and local engagement. Ministries of finance support budgeting and long-term funding, while emergency response units ensure rapid response and relief during water-related crises. Together, these actors form the institutional network needed to support resilient water systems.

Investing in Water-Resilient Systems

Cities can invest at **different budget levels**. Some resilience actions require relatively small investments, while others involve larger and longer-term infrastructure funding. The coin stacks illustrate how investment levels can scale depending on the type of intervention.

Figure 41. Different levels of investment for urban water resilience.

At the **first investment level**, cities can proof water systems from climate risk. The **second investment level** includes actions such as enhancing water transportation, strengthening spatial urban planning for water, and restoring ecosystems. At the **third investment level**, cities can enhance water access, increase water supply, and develop water resources such as groundwater. At the **fourth investment level**, investment focuses on increasing water storage.

Evaluating Water Resilience Financing

Cities should assess whether financing models support resilience without increasing inequality. Key questions include:

- Can systems recover costs without excluding vulnerable users?
- Are there opportunities for local water value chains and MSMEs?
- Are upstream water uses licensed and regulated?
- Are abstraction levels sustainable?
- Are withdrawal rules reviewed regularly to protect sources?

Evaluating Technical Capacity

Resilient systems require **strong technical and institutional capacity**. Cities need to assess whether they have skilled water management staff, adequate equipment and technical tools, and monitoring systems for water quality and supply levels. Technical capacity also depends on the ability to enforce land-use compliance and on the availability of financial resources to maintain infrastructure over time.

Key Takeaways: Water Resilience in Cities

This module highlights that **water resilience is not a one-time intervention**, but an ongoing process of planning, investment, coordination, and adaptation. Building resilient water systems requires cities to understand where water comes from, how risks are changing, and what institutional, financial, and technical capacities are needed to respond effectively.

Key takeaways from this module include:

- **Urban water resilience is an ongoing process**, not a one-time intervention.
- **Continuous monitoring** of water resources, pollution, abstraction levels, and equitable access is essential to guide decisions and adapt over time.
- **Building resilience requires active engagement of multiple actors**, with communities and municipalities supported by public institutions.

Module 6: Resilient Housing

Purpose of this Module

This module explores how rapid urban growth and climate change are shaping housing challenges in African cities. It introduces the key principles of climate-resilient housing and explains how planning, governance, financing, and community participation can support more resilient housing systems. By the end of the module, learners will gain practical insights into how cities can develop housing solutions that are **safe, affordable, and climate-resilient**, while responding to growing urban pressures.

Resilient Housing in African Cities

Across Africa, cities are expanding at an unprecedented pace. Rapid urban population growth is transforming settlement patterns, land markets, and infrastructure demand across the continent. At the centre of this transformation is the urgent need for **affordable housing** that can accommodate growing urban populations.

However, much of this expansion is happening through **informal development at the urban periphery,** often without adequate infrastructure, planning, or services. These settlements frequently face higher exposure to climate risks, as they are located in areas vulnerable to flooding, extreme heat, or landslides. As a result, housing challenges are not only about quantity, but also about **risk, safety, and long-term sustainability.**

Figure 42. Rapid urban growth and informal settlements increase exposure to climate risks in cities.

In this context, cities must move beyond simply building more housing. They need to develop housing systems that can withstand climate pressures while remaining accessible and inclusive. This means integrating resilience into housing design, planning, and investment decisions.

Strengthening housing resilience is therefore essential for ensuring safer living conditions, reducing vulnerability, and supporting sustainable urban development in rapidly growing cities.

Urban Housing Demand in Africa

Africa's cities are growing at an extraordinary speed. Urban populations have increased tenfold over the past fifty years, and millions of new housing units are needed to keep up with this expansion. Yet more than half of urban residents already live in informal settlements, often in areas exposed to climate risks.

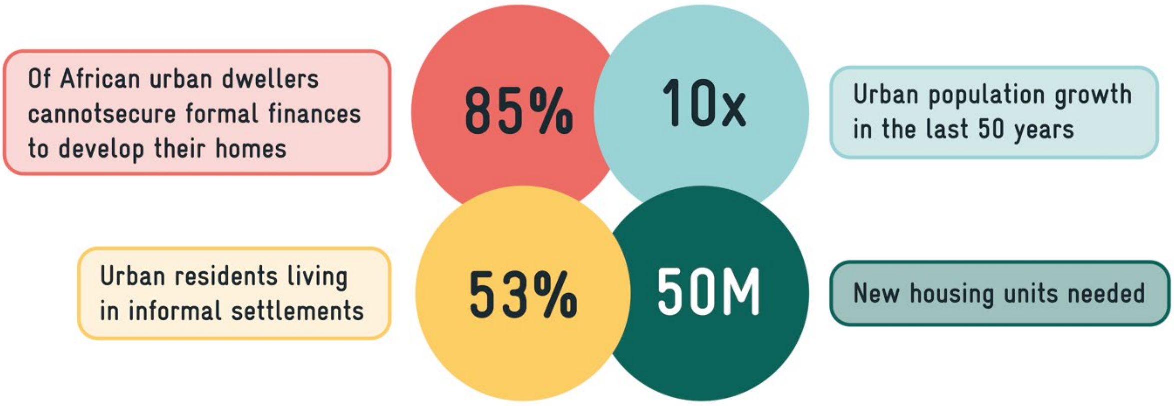


Figure 43. Key figures highlighting urban housing demand and informality in African cities.

How Climate Affects Housing

Climate change is intensifying risks for housing across African cities. Heavy rainfall and flooding can damage homes and infrastructure, while storm surges and rising sea levels threaten coastal areas. At the same time, extreme heat is making living conditions more difficult, particularly in dense neighbourhoods where buildings trap heat. In addition, drought reduces water availability, affecting both households and urban systems, and landslides can damage homes in unstable or poorly planned areas.

These hazards—**storms and strong winds, flooding, sea level rise, heat, drought, and landslides**—often occur in combination, increasing the vulnerability of urban populations. Understanding these risks is essential for designing housing that can better withstand current and future climate pressures.

Figure 44. Key climate hazards affecting housing in African cities.

These impacts are often **most severe in informal settlements**, where housing quality and infrastructure are limited. As a result, the people most exposed to climate risks are often those with the fewest resources to respond.

Cities must therefore shift from reacting to disasters to **planning housing that is resilient to future climate risks**. It is crucial that the investments made in the housing sector today are designed to withstand both current and future climate and extreme weather events.

What is resilient housing?

Resilient housing refers to housing that can withstand climate hazards, recover quickly after disasters, and adapt to the adverse effects of climate change or natural hazards such as flooding or extreme heat. However, resilience is not only about stronger buildings—it is also about how housing systems are planned, managed, and supported.

Resilient housing should therefore be understood as a system outcome, shaped by urban systems and governance. It depends on elements such as **land-use planning, infrastructure planning and maintenance, and building standards and their enforcement**. When responsibilities across these areas are fragmented, decisions can conflict. For example, upstream development may increase flooding downstream, or housing permits may be delayed across departments.

Building resilience requires **clear roles, strong coordination, and shared responsibility** across different actors involved in housing systems.

These roles include:

Who plans: City planning departments or urban development authorities that decide where housing can be built and how land is used. National governments may also play a role in setting building standards.

Who permits: Municipal building authorities that review designs and issue construction permits according to building codes and zoning rules.

Who pays: A mix of actors including public budgets (government), private developers and investors, banks, home-owners, microfinance institutions, and sometimes community savings groups.

Who maintains: Property owners, housing associations, municipal services, or community groups responsible for maintaining buildings, drainage, and shared infrastructure.

Cities often create **cross-department coordination platforms** linking housing, land, transport, water, and disaster management to ensure more coherent and resilient housing systems.

Principles of Climate-Resilient Housing

Climate-resilient housing focuses on how homes can be designed to be safer and better prepared for climate risks. It is guided by a set of key principles that help reduce vulnerability, improve living conditions, and ensure that housing can withstand and adapt to changing environmental conditions.

These principles go beyond individual buildings. They reflect how housing interacts with its surrounding environment, infrastructure systems, and resource availability. Together, they provide a practical framework for designing housing that is not only durable, but also adaptable, efficient, and responsive to local climate challenges.

The five principles—**site selection, robust structural integrity, passive design, self-sufficiency, and nature-based solutions**—offer a comprehensive approach to building housing that can better withstand current and future climate pressures.

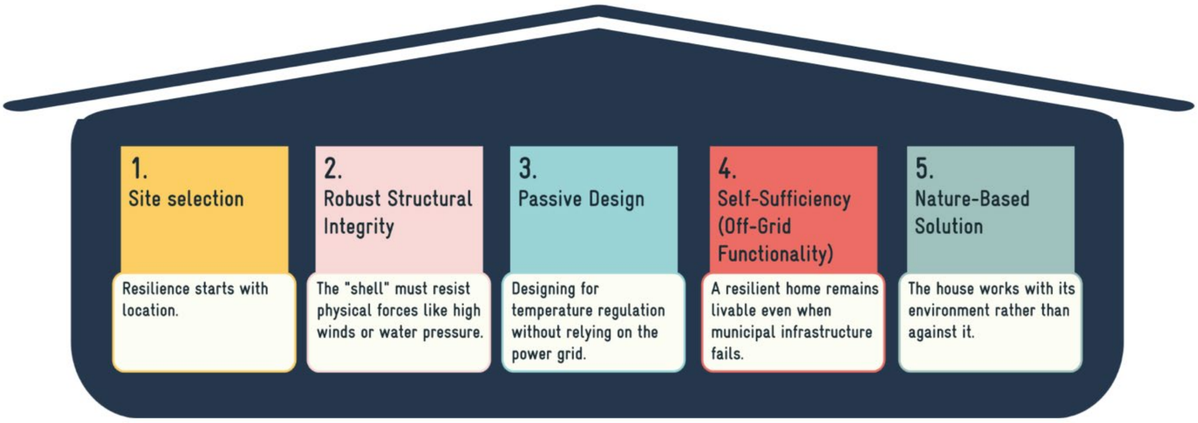


Figure 45. Key principles of climate-resilient housing

1) Site selection

Resilient housing begins with choosing the right location. Cities should use **risk mapping and urban planning t**o guide where and how housing is built. Risk mapping helps avoid development in areas exposed to major hazards, such as floodplains, unstable slopes, or low-lying coastal zones vulnerable to sea-level rise.

Figure 46. Avoiding high-risk areas significantly reduces exposure to flooding

Cities should also consider **relocating critical systems** above flood levels, especially in schools, hospitals, shelters, and emergency services buildings, which are essential for disaster response. In addition, urban design can help reduce climate risks. For example, cities can lower heat exposure by:

- Considering the **sky view factor** in street and building design
- Increasing **shade from neighbouring buildings and trees**
- Designing **street layouts that improve natural wind ventilation.**

2) Robust Structural Integrity

Resilient housing must be built to **withstand climate hazards**. The structure—or "shell"—should resist strong winds, flooding, and extreme heat. Cities can improve structural resilience through building design, material choices, and construction standards.

Homes should include **reinforced structural connections** that strengthen the link between roofs, walls, and foundations. For example: using **hurricane straps or anchor bolts** can secure roofs to walls, while reinforcing wall-to-foundation connections helps prevent structural failure during strong winds.

Using **durable and moisture-resistant materials** helps buildings maintain structural integrity during floods or heavy rainfall. Examples include earth blocks, bamboo, and recycled construction materials. Building standards should promote **robust and climate-resistant materials** adapted to local conditions.

In flood-prone areas, homes can be **elevated on raised platforms or stilts** to allow floodwaters to pass underneath without damaging the structure. This can be combined with **effective stormwater management systems**, such as infiltration trenches, retention ponds, or drainage improvements.

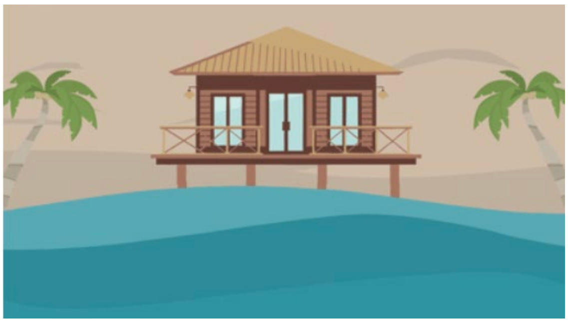


Figure 47. Elevating homes on raised structures helps reduce flood damage.

Buildings should also include **insulation and airtight construction** to reduce indoor heat exposure. These measures help maintain indoor comfort and **protect residents during extreme heat events.**

3) Passive Design

Passive design helps buildings regulate temperature and use water efficiently **without relying heavily on energy or external infrastructure.** Through smart design and materials, homes can stay cooler, more comfortable, and more resource-efficient.

Materials with **high thermal mass** absorb heat during the day and release it slowly at night. This helps stabilize indoor temperatures and reduce overheating. Avoiding glass and large windows can also help, as they tend to heat up buildings faster. For example, materials such as earth blocks, stone, and concrete walls can improve thermal performance.

Buildings can also be designed to encourage **cross-ventilation**, allowing air to flow naturally through rooms. Techniques include placing windows on opposite walls, using elevated ceilings, and incorporating ventilation openings that create **“chimney effects”** to expel hot air.

Existing buildings can improve comfort through retrofitting. For example, adding external shading such as trees, verandas, or shutters, improving roof insulation, enhancing ventilation, and installing energy-efficient windows can significantly improve indoor conditions.

Figure 48. Passive design strategies help keep homes cool and comfortable in hot climates.

Buildings should also include **insulation and airtight construction** to reduce indoor heat exposure. These measures help maintain indoor comfort and **protect residents during extreme heat events.** Housing design can also reduce water demand by incorporating:

- Water-efficient fixtures
- Rainwater harvesting systems
- Water storage tanks for greywater or rainwater reuse.

4) Self-Sufficiency (Off-Grid Functionality)

Resilient homes should remain functional even when city infrastructure fails. Designing housing systems that can operate independently helps communities **maintain essential services during disruptions.**

Figure 49. Solar power ensures energy access.

Homes can integrate **renewable energy systems** to maintain electricity during outages. For example, rooftop solar panels, battery storage systems, and small decentralized energy systems can support households and neighbourhoods.

Buildings can also improve water security through **rainwater harvesting and storage systems.** Examples include:

- Rooftop rainwater collection
- Storage tanks
- Greywater reuse for irrigation or cleaning

Homes should be designed to **maintain basic living conditions during shocks**, such as power outages, water shortages, or extreme weather events. This includes backup systems for **lighting, water access, and ventilation**.

Redundancy is also important: designing systems with backups ensures that if one part fails (e.g., a pump), the house can continue to function.

5) Nature-Based Solution

Climate-resilient housing should work with nature rather than against it. Integrating natural systems into neighbourhood design can **reduce climate risks while improving living conditions.**

Urban greenery near buildings helps reduce **heat stress** by providing shade and cooling through evapotranspiration. For example, street trees, parks, green corridors, and urban gardening can lower temperatures and improve comfort in dense urban areas.

Green roofs and vertical vegetation can help **lower indoor temperatures**, improve insulation, and manage rainwater. They also contribute to better air quality and urban biodiversity.

Figure 50. Green walls help cool buildings naturally.

Nature-based drainage can help cities manage stormwater and reduce flood risks to buildings. Examples include:

- Permeable surfaces that replace concrete with gardens or porous pavers to allow rainwater to soak into the ground
- Bioswales
- Retention ponds
- Restored wetlands

Neighbourhood design can also incorporate **natural buffers and green infrastructure** to protect housing from climate risks. Examples include:

- Coastal mangroves
- Restored riverbanks
- Green floodplains

These approaches show how working with natural systems can strengthen resilience while delivering additional environmental and social benefits.

Community-driven housing and social resilience

Housing resilience improves when communities participate in shaping solutions. Key approaches include:

- **Participatory planning**, which involves residents in housing and neighbourhood decisions.
- **Informal settlement upgrading**, which focuses on improving existing housing rather than replacing communities.
- **Gender-inclusive housing**, ensuring that housing responds to the needs of women and vulnerable groups.
- **Livelihood integration**, linking housing with access to jobs and services.

This approach is particularly important because, in many cities**, low-income households make up the majority of urban residents**, yet they often lack access to formal housing finance. Strengthening housing resilience therefore requires combining **market-based housing solutions with public investment, social housing policies, and inclusive financing**.

Protecting vulnerable communities

Residents in informal settlements often face double risks: **climate hazards and eviction pressures**. Resilient housing strategies should therefore focus on protecting, upgrading, and supporting existing communities rather than displacing them.

Participation plays a central role in this process and must be both **accessible** and **inclusive**. This means that processes, spaces, and information are designed so that **everyone can participate**, regardless of physical ability, language, location, or time constraints. It also involves removing barriers such as inaccessible venues, complex language, or inconvenient meeting times. At the same time, participation should actively **ensure that diverse groups are represented and involved in decision-making**, especially those who are often excluded, such as women, youth, persons with disabilities, and low-income communities.

In practice, this may include:

- Meetings at accessible times and locations
- Materials in plain language
- Childcare support
- Sign-language interpretation
- Inclusive engagement of women, youth, older persons, and persons with disabilities

By ensuring participation is both accessible and inclusive, cities can design housing solutions that better reflect community needs and strengthen long-term resilience.

Policy, finance and governance

Building climate-resilient housing requires more than good design. Cities also need the **right policies, financing mechanisms, and governance systems** to support and scale resilient housing solutions.

Financing resilient housing

Financing strategies should reflect the diversity of actors and the financial realities of low-income households. Different sources of finance can support resilient housing:

- **Public investment** for trunk infrastructure, nature-based systems, and inclusive design features
- **Private developers and lenders** financing housing construction when risks are predictable
- **Community finance**, such as savings groups and housing cooperatives supporting incremental upgrading

Examples of financing tools include green finance, micro-loans and subsidies, and public–private partnerships.

Governance and regulation

Strong governance helps cities design, implement, and enforce resilient housing policies. Key actions include:

- Climate-responsive housing policies
- Updated building codes and zoning regulations
- Better coordination between institutions responsible for housing, land, and infrastructure

These frameworks help ensure that resilience standards are applied consistently across urban development.

One practical entry point is to **start with public buildings**. Cities can begin by retrofitting municipal buildings, such as schools or hospitals, which can serve multiple functions, including serving as cooling centres during extreme heat and as emergency shelters during storms or disasters. Pilot projects can also help **cities test resilient design solutions and showcase approaches that can later be applied to housing at scale**.

Case Study: Climate-Resilient Housing in Lagos, Nigeria

Lagos, Nigeria's largest city, is one of the **fastest-growing urban areas in the world**, with more than **20 million residents.** Rapid urban population growth has significantly increased housing demand, but housing development has struggled to keep pace. As a result, many residents live in informal settlements where housing quality and infrastructure are limited.

Figure 51. Flooding and heavy rainfall increase housing vulnerability in Lagos.

The city's geography further increases its vulnerability. Lagos is located on a **coastal lagoon system**, with many areas lying only slightly above sea level. Combined with heavy rainfall and inadequate drainage systems, this makes the city highly exposed to **flooding**. Climate change is intensifying these challenges, with more frequent and intense rainfall overwhelming infrastructure, increasing coastal flooding and sea-level rise, and contributing to land subsidence and erosion. At the same time, densely built neighbourhoods are experiencing extreme heat, further affecting living conditions.

In response to these challenges, the Lagos State Government has introduced several initiatives to improve housing supply and strengthen urban resilience. Key policy actions include **expanding affordable housing programmes, improving urban planning and land-use regulation, investing in drainage and flood management infrastructure**, and integrating climate considerations into urban development planning.

Financing remains a critical challenge in addressing housing needs at scale. Lagos has explored multiple financing approaches, including partnerships with private developers, mortgage programmes and housing finance schemes, public investment in infrastructure and housing estates, and collaboration with development partners. These efforts aim to combine public and private resources to support **large-scale housing development**.

Figure 52. Improved planning and infrastructure help reduce climate risks in Lagos.

Resilient housing in Lagos also focuses on reducing exposure to climate risks through improved design and planning. This includes strengthening **stormwater drainage systems, improving site**

selection and land-use planning, and developing housing designs adapted to flooding and extreme weather conditions.

The experience of Lagos highlights several important lessons. Building climate-resilient housing **requires coordinated action across multiple sectors.** Cities need to integrate climate risk into housing planning, strengthen urban governance and institutional coordination, mobilise diverse financing mechanisms, and improve infrastructure and land-use planning alongside housing development.

As Lagos demonstrates, addressing housing challenges in rapidly growing cities requires not only expanding housing supply, but also ensuring that housing is **safe, inclusive, and resilient to climate risks.**

Passive cooling for heat resilience

In cities like Lagos, rising temperatures and limited access to electricity make cooling a critical challenge for housing.

The challenge: Extreme heat: indoor temperatures in Nigerian cities **often exceed 30°C without mechanical cooling,** making homes uncomfortable and sometimes unsafe. An estimated 114.9 million people (53% of the population) are at high risk from extreme heat. At the same time, many households lack reliable electricity for air conditioning, limiting their ability to cope with rising temperatures. As a result, **affordable cooling solutions are essential for improving living conditions in urban housing.**

Policy response: in response to these challenges, Nigeria introduced the Building Energy Efficiency Code in 2017. The code promotes passive building design, encourages energy-efficient construction, and aims to reduce reliance on mechanical cooling systems. These measures support more sustainable and accessible approaches to managing heat in urban housing.

Passive cooling solutions tested in Lagos: research and pilot projects show that passive strategies can significantly improve indoor comfort. Key approaches include:

- **Natural ventilation** through building orientation and window placement
- **Passive cooling design** in social housing projects such as Jakande Housing Estate
- **Green roofs** and green façades that reduce heat absorption

Studies have found that green walls can reduce indoor temperatures by about 2.3°C, improving comfort while also lowering energy demand.

Further resources

For those interested in exploring this topic further, several studies and resources provide deeper insights into passive cooling and climate-resilient housing in Lagos and other African cities. These include key policy documents, research studies, and practical case examples.

Some recommended resources are:

- Lagos State Government Climate Adaptation and Resilience Plan (2024)
- Chilling Prospects: Sustainable cooling in buildings and cities – Nigeria case study (Sustainable Energy for All)
- Enhancing Thermal Comfort in High-Rise Condominiums Through Passive Design Strategies in Lagos, Nigeria (IIETA)
- Utilization of Natural Ventilation Strategies for Improving Thermal Comfort and Energy Efficiency in Low-Cost Housing in Lagos State, Nigeria (ABUAD Journal of Social and Management Sciences)

These resources provide **practical examples, technical guidance, and research findings** that can support the design and implementation of climate-resilient housing solutions.

Key points

As cities continue to grow and climate risks intensify, building resilient housing becomes essential for protecting people, improving living conditions, and ensuring sustainable urban development. The following key points summarize the main insights from this module:

- Africa's rapid urban growth is creating an urgent demand for affordable housing. Much of this expansion is occurring in informal settlements that often lack services and are exposed to climate risks.
- To protect communities, housing must be designed to **resist, adapt, and recover from climate hazards** such as flooding, extreme heat, and storms.
- Resilient housing is not only about buildings. It also depends on **urban planning, infrastructure, land governance, and building standards.**
- Successful housing solutions **require strong governance, financing mechanisms, and active participation** from communities.