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Urban Climate Resilience Masterclass

Module 5

Step-by-Step Guidelines for
Delivering Climate Resilient Infrastructure

Photo by Sushavan Nandy, NurPhoto

UCRMC Course Overview

Welcome to the Urban Climate Resilience Masterclass! You are about to start **Module 5**.



Module 1

Introduction to
Climate
Change and
Urban
Resilience



Module 2

Understanding
Climate Risks
in Your City



Module 3

Locally Led
Adaptation for
Urban
Resilience



Module 4

Ensuring
Climate
Resilience of
Urban
Infrastructure



Module 5

Step-by-Step
Guidelines for
Delivering
Climate
Resilient
Infrastructure



Module 6

Financing
Climate
Resilient Urban
Infrastructure

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GFDRR
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The Institution of Engineers of Kenya



These contributions were instrumental in ensuring the relevance and quality of the UCRMC Modules.

Agenda

- 01 Why This Topic Matters
- 02 Learning Objectives
- 03 Entry Points for Promoting Climate Resilience
- 04 Business as Usual vs. Climate Resilient Infrastructure
- 05 Step-by-Step Guidelines for Delivering Climate Resilient Infrastructure
- 06 Decision-Making Under Uncertainty
- 07 Interactive Exercise
- 08 Summary



Photo by AFP

Housekeeping

Listen



Listen carefully, follow along and make your own notes.

Ask



Ask the trainers questions or clarifications at any time.

Share



Your own experience is valuable and we encourage you to share it.

Discuss



Share and discuss with others during exercises, breaks and reflections.

01 | Why This Topic Matters



Why This Topic Matters



Building on the introduction to climate resilient infrastructure in Module 4, this module provides you with actionable guidelines and processes to deliver climate resilient infrastructure in your city.



It outlines different entry points for integrating resilience into decision-making in your city – including policies, planning, and asset creation. It then dives deep into how to plan and deliver climate resilient infrastructure.



This module presents a series of step-by-step guidelines for you to use when making infrastructure investments to ensure they are climate resilient.



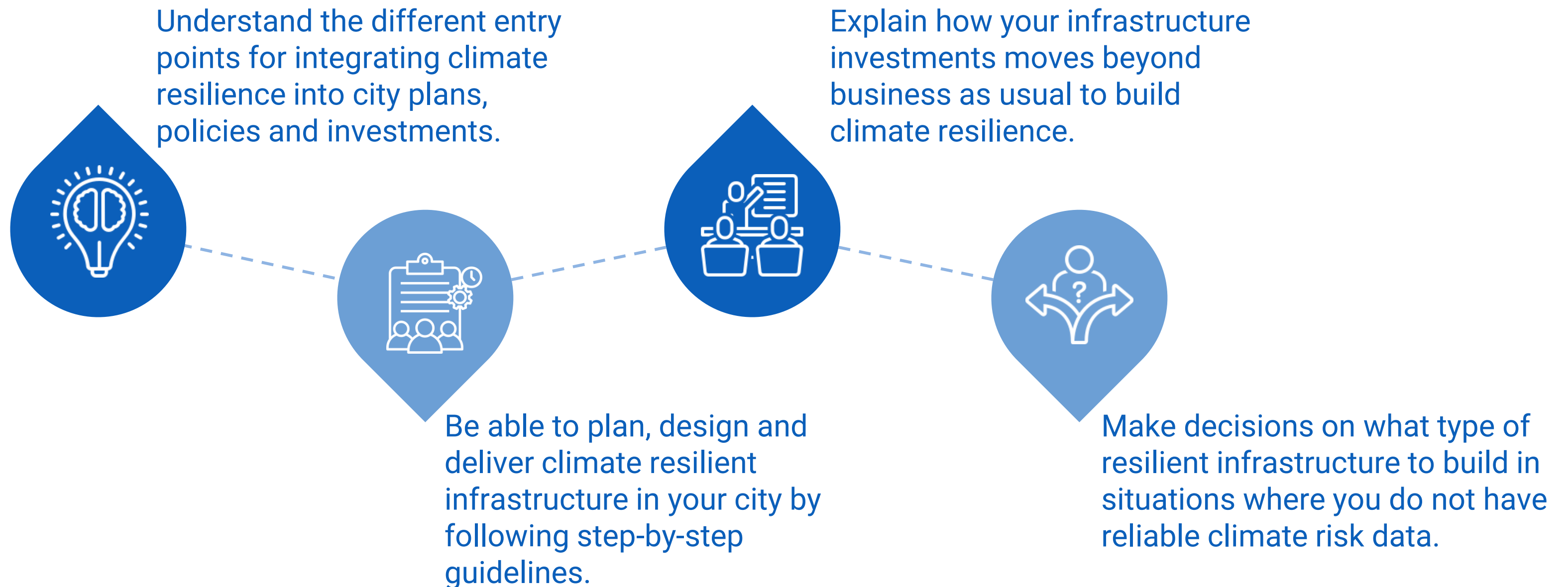
It also gives you a framework that you can use to decide what type of climate resilient infrastructure you can deliver even in situations where you do not have access to a CRA or climate risk data to guide your decision.

02 | Learning Objectives



Learning Objectives

By the end of Module 5 participants will be able to:



03 | Entry Points for Promoting Climate Resilience in Cities



Photo by Stephane Bidouze, Canva

Entry Points for Promoting Climate Resilience



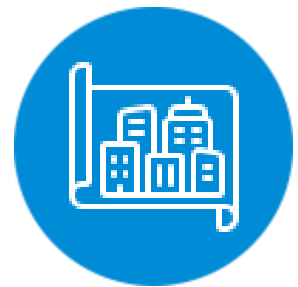
Policies & Strategies

Developing policies and strategies at national and city levels that outline how to address current and future climate risks.



Building Standards, Codes & Guidelines

Setting standards and guidelines like building codes so that infrastructure is constructed in a way that manages future climate risks.



Urban Planning

Integrating resilience into long-term urban plans such as city/urban plans, capital expenditure plans and disaster risk reduction plans.



Investing in Infrastructure

Planning and delivering climate resilient infrastructure so that it can withstand current and future climate impacts and minimizes climate risks for citizens.

Entry Point 01 | Policies & Strategies

Policies & Strategies

Many cities have developed their own climate policies, strategies, and action plans. These climate action plans work towards delivering the Paris Agreement – the international framework to combat climate change signed by all countries in the world.

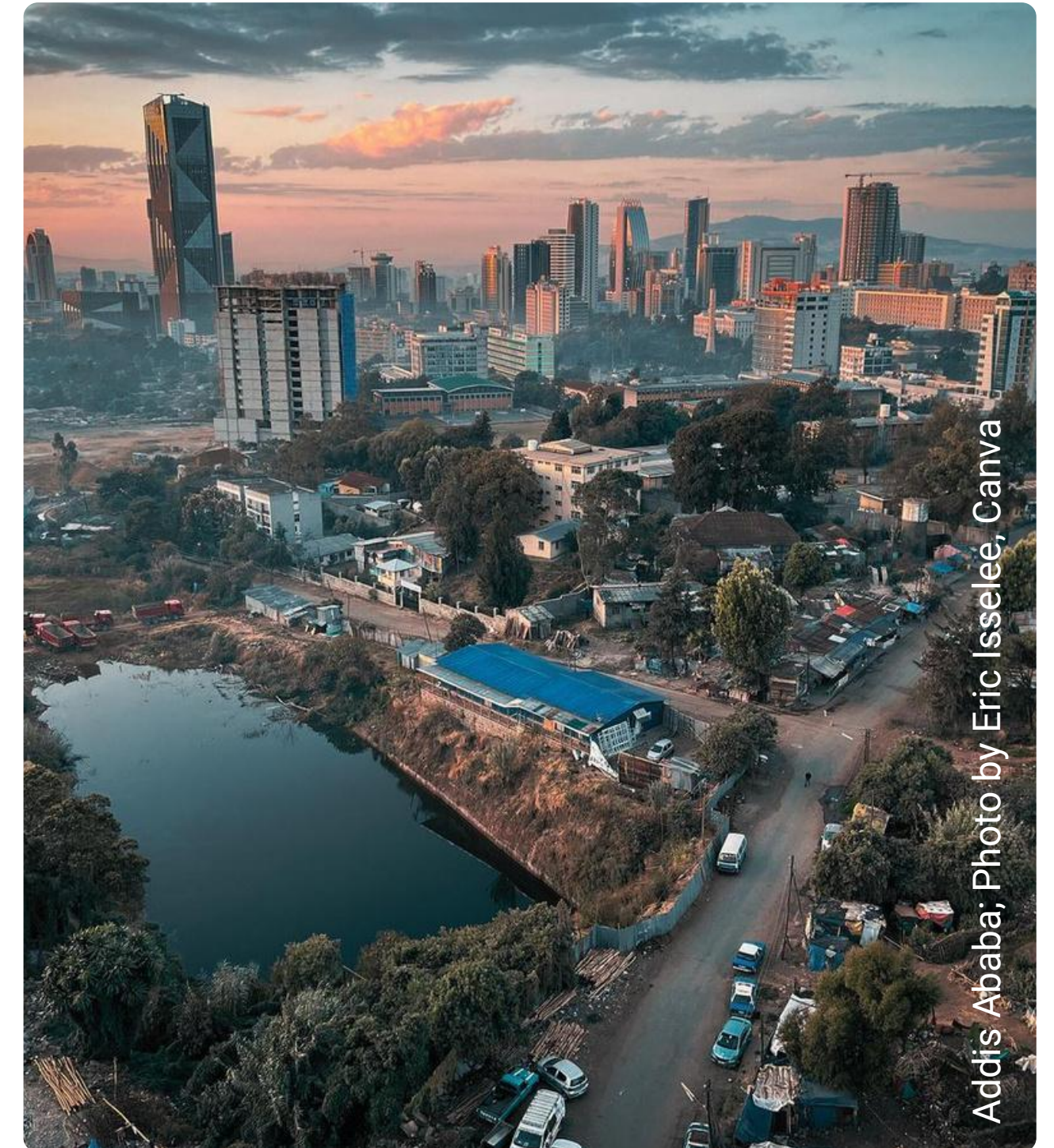
By developing a climate policy, strategy, or action plan, cities can organize their strategic approach to responding to climate change, and can set goals, timelines and investments that will promote climate resilience and reduce greenhouse gas emissions.

Case Study | Addis Ababa

Ethiopia's capital city has developed the [Addis Ababa Climate Action Plan: Towards a Climate Resilient, Inclusive, Low Carbon City by 2050.](#)

The plan has an overarching resilience goal:

“To reduce the impacts of climate hazards such as flooding, heatwaves and droughts on different sectors, with targets the vulnerability to hazards by 30% in 2030, 60% in 2040 and 100% in 2050.



Addis Ababa; Photo by Eric Isselee, Canva

Entry Point 02 | Urban Planning

Urban Planning

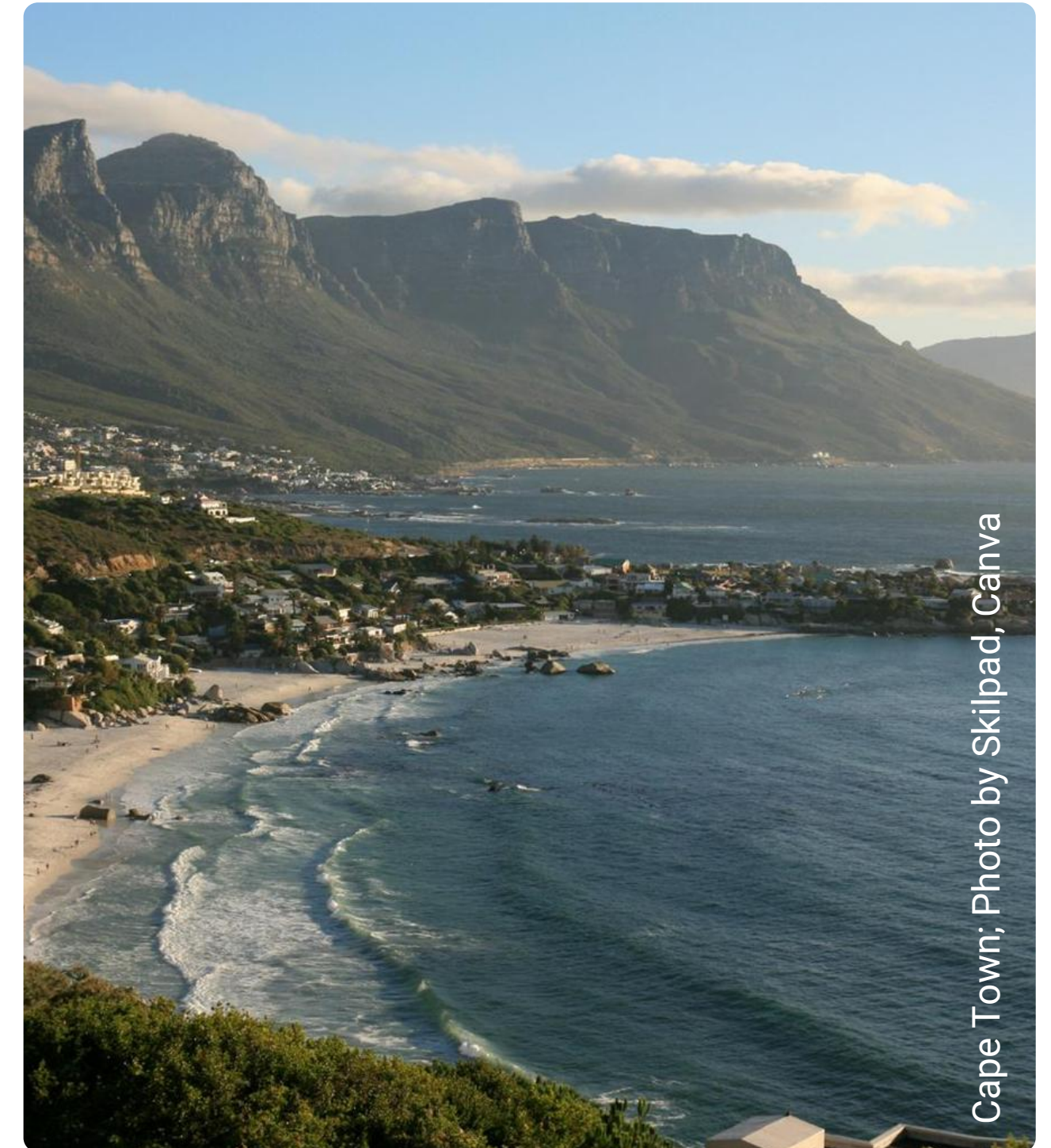
In addition to strategic climate plans, cities can also integrate climate resilience into urban planning processes – such as urban Master Plans that guide spatial planning, and capital investment plans that guide medium-to-long-term infrastructure investments.

These are important entry points for ensuring that climate risk is systematically addressed across department silos and over longer time horizons that move beyond single government mandates.

Case Study | Cape Town

Cape Town's coastline is vital to the city's economy, but also vulnerable to climate risks such as rising sea levels, storms and erosion.

Cape Town has integrated climate risk management into spatial planning by delineating a Coastal Management Line (CML). City planners integrate climate risk data into coastal planning and regulate development within the CML to minimize risks while promoting equitable human settlements.



Cape Town; Photo by Skilpad, Canva

Entry Point 03 | Standards, Codes & Guidelines

Standards, Codes & Guidelines

The impact of climate hazards will take a toll on infrastructure in cities.

Standards, codes & guidelines can play an important role in building resilience by setting the rules to ensure that the location, design, materials, construction and operation of infrastructure all promote resilience.

Guidelines could include locating infrastructure away from flood risk areas or ensuring buildings are built with storm-resistant materials.

Case Study | New York City, USA

In 2012, Superstorm Sandy hit New York City, destroying 300 homes, killing 44 people, damaging infrastructure, leaving hundreds of thousands without power or basic services and causing USD \$44 billion in damages.

Following Superstorm Sandy, New York City upgraded its building codes to increase coastal resilience so that new buildings and retrofitted buildings are resilient to future hurricane impacts.



New York City; Photo by rabbit75_ist, Canva

Entry Point 04 | Climate Resilient Infrastructure

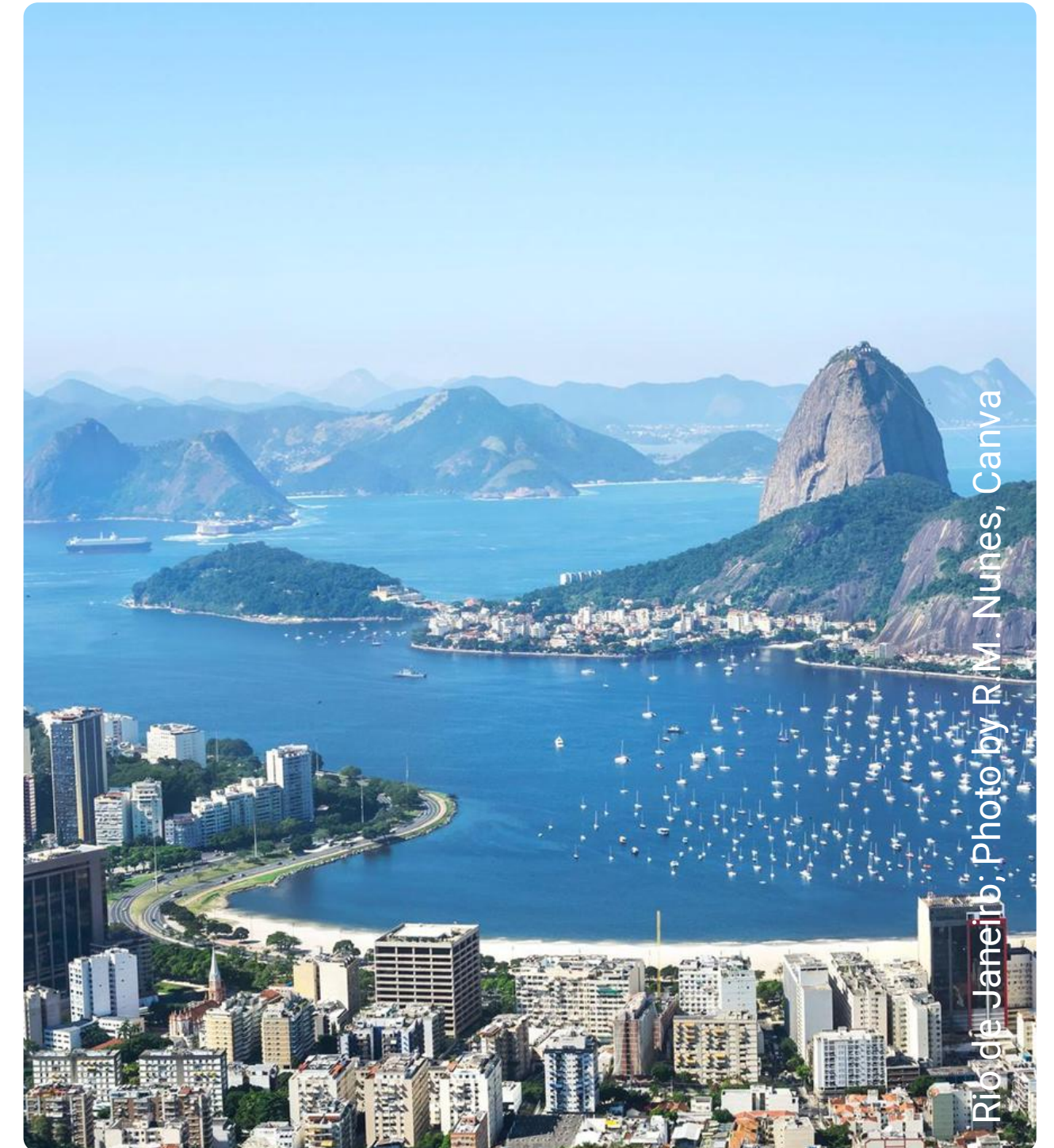
Climate Resilient Infrastructure

City officials can plan, design and deliver infrastructure and services that reduce the vulnerability and exposure of the city and its inhabitants to climate hazards.

Climate resilient infrastructure can have two facets: infrastructure can be designed so it is not negatively impacted by climate hazards (climate proofing); and the infrastructure can help reduce climate risks so that citizens are less impacted by climate change.

Case Study | Rio de Janeiro

Rio de Janeiro has built a range of flood-prevention infrastructure, including underground reservoirs and a diversion tunnel, preventing flooding into city streets, infrastructure damage, and the spread of waterborne diseases. The reservoirs are also used for recreation, demonstrating the dual functionality of infrastructure in enhancing both resilience and urban livability.





This course focuses on infrastructure investments as the main entry point.

But you may be able to contribute to building resilience in your city through other entry points too.

Review Exercise

Take 10 minutes to:

→ Write down a list of things your city is doing to promote climate resilience.

→ Discuss the list with the person beside you.

→ Share any thoughts to the wider table, and listen to what other cities are doing too.



Policies & Strategies

Developing policies and strategies at national and city levels that outline how to address current and future climate risks.



Building Standards, Codes & Guidelines

Setting standards and guidelines like building codes so that infrastructure is constructed in a way that manages future climate risks.



Urban Planning

Integrating resilience into long-term urban plans such as Master Plans, capital expenditure plans and disaster risk reduction plans.



Investing in Infrastructure

Planning and delivering climate resilient infrastructure so that it can withstand current and future climate impacts and minimizes climate risks for citizens.

04 | Business as Usual vs. Climate Resilient Infrastructure



Photo by Jim Feng, Getty Images (licensed via Canva)

BAU Infrastructure Planning & Delivery Steps

1|

Strategy

2|

Plan

3|

Design

4|

Build

5|

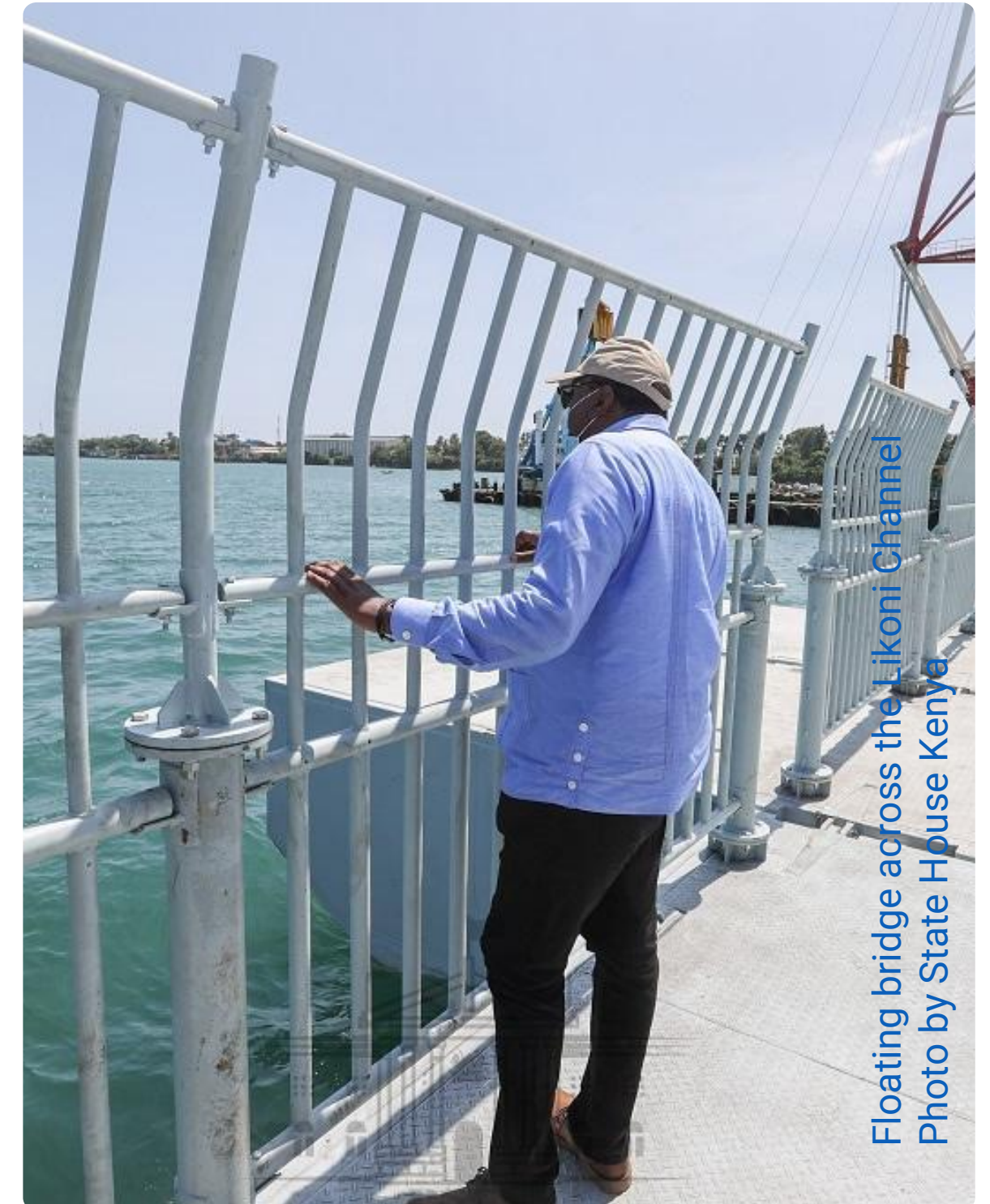
Operate & Maintain

6|

Decommission /
Upgrade

Business As Usual Approach

1. Identify long-term infrastructure investment needs in the city – e.g. through a capital investment plan or a spatial plan.
2. Conduct project feasibility study & consult with stakeholders.
3. Technical engineering design of asset.
4. Construct infrastructure asset in line with design specifications.
5. Operate infrastructure asset over its lifespan.
6. Decommission asset or upgrade with new infrastructure strategy.



Floating bridge across the Likoni Channel
Photo by State House Kenya

Climate Resilient Planning & Delivery Steps



05 | Step-by Step Guidelines for Delivering Climate Resilient Infrastructure in Kenya



Construction of sea wall to protect historical site in Malindi;
Photo by Kenya News

Step 01 | Strategy

Business As Usual Approach

According to the Urban Areas and cities Act (2011) a city/municipal board or town committee shall within the first year of its appointment prepare and adopt an inclusive, strategic integrated development plan for the development of the city or urban area under its jurisdiction. The plans should be aligned to the development plans and strategies of the county governments.

The city/municipal board/town committee will identify long-term infrastructure investment needs through an city or urban integrated development plan (Refer to Urban areas and cities Act no. 13 of 2011, Part V; County Governments Act of 2012, Section 111; Physical and Land Use Planning Act of 2019, Sections 45-51).

This phase may entail outsourcing to qualified professionals/firms to undertake the preparation of the city/urban integrated development plans. The board should adhere to the relevant public procurement process as stipulated in the Public Procurement and Asset Disposal Act Cap 412C (Refer to Part VII, VIII, IX, X and XI).

Climate Resilient Approach

Develop a municipal Climate Action Plan or city Climate Strategy

Conduct a climate risk screening of high-level climate risks in the city, municipality or town.

Identify high-level resilience goals in line with national, county or city/municipal climate policies and plans. For example:

- The National Climate Change Policy.
- National Adaptation Plan 2015-2030.
- County Climate Change Policies.
- County Climate Action Plans.

Step 01 | Strategy cont'd...

Business As Usual Approach

The board/town committee will consult with relevant stakeholders, including conducting public participation forums during the integrated development planning process to identify the infrastructure projects.

The County Executive committee member in-charge of city/municipal planning will ensure the city/urban integrated development plan receives the relevant regulatory approvals at the city/municipal and county levels. The plans are subject to annual review as stipulated in Section 42 of the Urban Areas and cities Act.

The city/municipal board will ensure timely preparation of the proposed project implementation budget taking cognizance of the government budgeting cycle and city/municipality's budget guidelines.

The city or municipal board will submit the budget to the finance department for inclusion in the overall budget. The budget must also undergo mandatory public participation and receive regulatory approval at both city/municipal and county levels.

Climate Resilient Approach

Develop a municipal Climate Action Plan or city Climate Strategy to set high-level resilience goals and identify strategic sectors & interventions.

Conduct a climate risk screening of high-level climate risks in the city, municipality or town.

Identify high-level resilience goals in line with national, county or city/municipal climate policies and plans. For example:

- The National Climate Change Policy.
- National Adaptation Plan 2015-2030.
- County Climate Change Policies.
- County Climate Action Plans.

Step 01 | Strategy

Case Study | Wajir County Climate Action Plan

Wajir has recently developed its County Climate Action Plan 2023-2027.

The Plan identifies 5 strategic priorities for the County to address climate change:

1. Disaster risk management related to floods and drought
2. Food and nutrition security
3. Availability and access to clean water
4. Forestry, wildlife and tourism; and
5. Health, sanitation & human settlements

Each of the adaptation & resilience measures have been assigned specific projects, locations, budgetary allocations, responsible stakeholders and target groups.



Wajir; Photo by Jervis Sundays, Kenya Red Cross Society

Step 01 | Strategy

Case Study | Wajir County Climate Action Plan

Climate change priorities	Priority actions	Adaptation/mitigation measures	Budget (Ksh)
Drought and Floods Risk Management	Increase the number of households and entities benefiting from devolved adaptive services, including HSNP and County Climate Change Funds.	- Establishment of early warning systems - Flood water harvesting - Food and nutritional supplements, such as school feeding programmes - Protection of river riparian areas - Insurance systems for livestock	275 Million
Reduce risks to communities and infrastructure resulting from climate-related disasters such as droughts and floods	Improve the ability of people to cope with drought.	- Establishment of early warning systems - Afforestation and reafforestation	185 Million
	Improve the ability of people to cope with floods.	- Strategic placement of dams / dykes - Storm water drainage systems and stormwater harvesting	75 Million
	Improve coordination and delivery of disaster management response.	- Implementation & upscaling of disaster management bill - Develop disaster management plan/policy	130 Million
	Diversify livelihoods to adjust to a changing climate	- Adopt climate-smart agriculture (agroforestry, drought tolerant crops, conservation agriculture) - Establish irrigation systems (e.g. construction of dams for irrigation, and up- scale drip irrigation) - Enhance agricultural extension services	20 Million

Step 02 | Plan

Business As Usual Approach

After the approval of the city/urban integrated development plans, Conduct project feasibility studies. This should entail an analysis of technical, economic, legal, operational, and time feasibility factors of the project.

The phase may entail outsourcing to qualified professionals/firms to undertake the feasibility studies. In case of outsourcing, ensure to follow the relevant public procurement process as stipulated in the Public Procurement and Asset Disposal Act Cap 412C (Refer to Part VII, VIII, IX, X and XI).

Consult with relevant stakeholders including conducting public participation forums.

Present the results of the feasibility study to the city/municipal board outlining the appropriate climate adaptation/resilience options to be implemented alongside the project.

Conduct an environmental and social impact assessment for the proposed project and obtain relevant regulatory approvals.

Climate Resilient Approach

Conduct a climate risk assessment (CRA) to identify high-level climate risks in the city/municipality/town.

In case of outsourcing CRA, ensure to follow the relevant public procurement process as stipulated in the Public Procurement and Asset Disposal Act Cap 412C.

Based on the CRA, identify relevant adaptation or resilience options that the city plans to undertake. Some CRAs may include a ranking or list of resilience options for the city.

City officials could use existing guidelines, such as the Integrated and Inclusive Infrastructure Framework (3iF) to help plan sustainable infrastructure,

Step 02 | Plan

Case Study | Wajir Climate Risk Assessment

As part of its County Climate Action Plan 2023-2027, Wajir undertook a participatory climate risk assessment (PCRA).

The climate risk assessment identified the following climate risks in Wajir: floods; drought; environmental degradation; human disease; livestock and crop disease.

The CRA used the following sources of climate data:

- Hazard maps from RCMRD
- Meteorological data from Kenya Meteorological Department
- Indigenous knowledge on seasonal weather events

The CRA identified various adaptation and resilience options as shown on the next slide.



Wajir; Photo by Riccardo Gangale, ILRI

Step 02 | Plan

Case Study | Wajir Climate Risk Assessment

Risk/hazard	Sector	Resilience strategies	Stakeholders applying strategy
Drought	Water	- Increasing water sources through drilling of boreholes, excavation of mega water pans, desilting of existing pipes - Water harvesting - Use of renewable energy in boreholes and water pans to reduce running cost as well enhance efficiency - Use of water efficient irrigation practices such as drip irrigation - Capacity building of water user associations	County Government National Drought Management Authority Kenya Red Cross Society WFP Mercy Corps ELRP RPLRP
Environmental Degradation (Deforestation, soil erosion)	Environment	- Employment and deployment of forest rangers - Adoption of alternative source of energy - Practice agroforestry. - Community sensitization on climate change - Increase forest cover through afforestation - Practice sustainable land management	County Government Kenya Forest Service WFP

Step 03 | Design

Business As Usual Approach

This stage entails technical engineering design of asset. It could be designed directly by the municipality (e.g. Public Works Department) or by a qualified engineering firm identified through a competitive procurement process.

In case of outsourcing, the city/municipal engineering team should draft an Expression of interest for tender to firms interested in undertaking the design of the assets. The city/municipal authority should follow the tendering process as stipulated in the Public Procurement and Asset Disposal Act Cap 412C.

Upon award of tender the selected engineering firm should in consultation with the city/municipal public works team design the asset.

Seek relevant regulatory approvals for the technical engineering design if required.

Climate Resilient Approach

Select preferred climate resilient infrastructure or service from options outlined in CRAs, or from national, municipal and sectoral strategic plans.

Ensure that the technical engineering design takes into consideration current and future climate risks, based on data from CRAs or using the 'decision-making in contexts of uncertainty' framework.

Design options could be structural, non-structural or nature-based solutions (NbS).

Step 03 | Design

Case Study | Municipal Market Design | Homabay

The Homabay municipal market has been designed in a manner that addresses climate risks of heat stress, flooding and erosion.

In its structural design, expansion joints have been included to provide for volumetric changes due to temperature variations. The design has also considered natural ventilation.

Rooftop rainwater harvesting has been provided as supplementary water supply and to reduce pressure on existing water resources systems during drought.

Trees have been planted along access roads and landscaping included in the design to provide greening and cooling effect in the otherwise hot and dry town.

Stormwater drainage system has been provided to prevent flooding during heavy precipitation, and steep earth faces stone have been provided for protection against soil erosion.



Homabay Town Market; Photo by Kenya News Agency

Step 04 | Build

Business As Usual Approach

This stage entails construction of the asset. It may be built by the city (e.g. Public Works Department) or outsourced to a qualified construction firm. If outsourced, the city should follow the proper procurement process to award the tender for construction.

The city/municipal public works team should ensure construction quality control to guarantee that project deliverables meet the standards and guidelines set by the city/municipal authority at the beginning of the construction process.

The city/municipal public works team should have a project inspection plan and conduct regular inspections as part of quality assurance plan. Corrective actions should be undertaken in case of any defects during the construction phase

A certificate of completion of works should be issued upon satisfactory completion of the construction phase

Project commissioning: the construction team should handover the asset to the city/municipal authority

Climate Resilient Approach

Incorporate the preferred adaptation / resilience options into the construction of the asset.

Construct infrastructure asset with climate resilient design option.

Step 04 | Build

Case Study | Kaimosi solar water project | Vihiga

The project involved installation of solar panels to facilitate water pumping and reduce water stress.

It uses solar energy to pump water from the main water supply stations to reduce the cost of making water accessible to consumers.

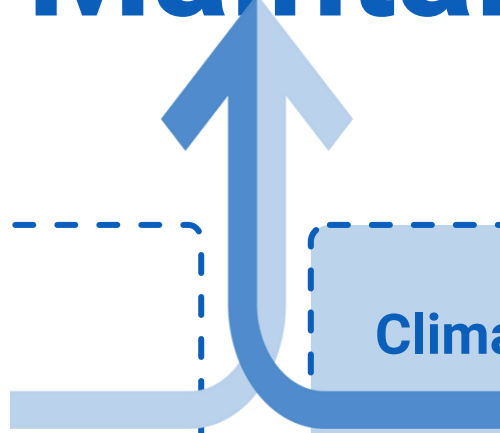
The installation has harnessed solar energy instead of using electricity to pump water thus reducing the cost of water distribution by half (the power bill is down from KSh. 500,000 to KSh. 250,000).

The project has capacity to supply 7.5 million litres of water per day. This has enabled 300,000 residents to have access to clean, safe, and affordable piped water.



Vihiga; Photo by Maarifa Centre

Step 05 | Operate & Maintain



Business As Usual Approach

This stage entails operation & maintenance of the asset upon commissioning.

The city/municipal authority should ensure continuous monitoring of asset performance over the lifespan of the asset.

Prepare a maintenance schedule and undertake timely asset repair and maintenance works.

Climate Resilient Approach

Ensure continuous monitoring to assess performance of the asset under current & future climate conditions.

Ensure continuous monitoring of climate risk (hazard, exposure & vulnerability) to determine risk management strategy.

Update climate risk registers.

Decided whether resilience options need to be adjusted, in line with adaptive management.

Integrating monitoring outcomes into annual/5-year budgets.

Request more resources for resilience if needed.

Step 05 | Operate & Maintain

Case Study | Nairobi-Ruiru Commuter railway

The Kenya Urban Mobility Improvement Programme aims at integrating resilience in the operation and maintenance of the commuter rail system within the Nairobi Metropolitan area. It is being piloted in the Nairobi-Ruiru railway corridor.

The project incorporates adaptive management practices by continuously monitoring traffic patterns, transportation needs, and climate impacts.

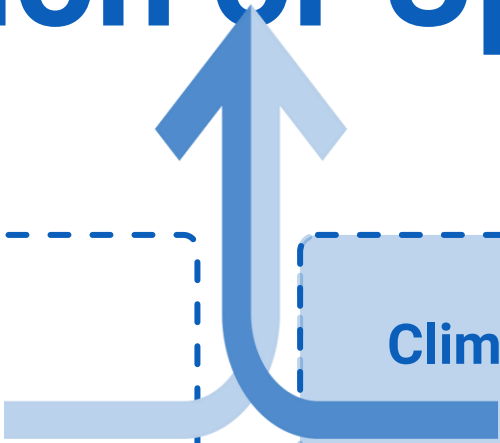
It focuses on road and rail rehabilitation, construction of pedestrian walkways and bicycle lanes, and improving drainage systems to mitigate flooding risks during heavy rains.

A monitoring and evaluation plan has been proposed to assess the impact of infrastructure improvements on urban mobility, road safety, and environmental sustainability.



Photo by NMS

Step 06 | Decommission or Upgrade



Business As Usual Approach

This stage entails decommissioning or upgrading the asset.

The city/municipal authority should decommission the asset if it is no longer performing its function or is no longer financially viable.

The city/municipal authority should upgrade the asset in line with new infrastructure strategy and investment in its urban master plan.

Climate Resilient Approach

Conduct a lifecycle analysis on proposed and existing investments to compare business-as-usual investments with greener alternatives for upgrading.

Decommission the asset if climate risks are so severe that it makes the asset no longer functional or financially viable.

Upgrade asset over time with new data on climate risks (if it is feasible and financially viable), in line with the principle of adaptive management.

Ensure that infrastructure upgrades incorporate climate resilient design features to make it more resilient to future climate hazards and risks.

Step 06 | Decommission or Upgrade

Case Study | Kibarani Dumpsite | Mombasa

In 2020, Mombasa city successfully reclaimed the 50-year-old, 12-acre Kibarani dumpsite, located in the strategic area of Makupa causeway along the Indian ocean, into a public recreational park through partnership with local private sector stakeholders.

The dumpsite was converted into a new ecological park, which provides recreational space for the public, and turns the old landfill into a thriving public space in Mombasa.

This case study highlights how a city can upgrade infrastructure at the end of its lifespan.



Transformed Kibarani Dumpsite; Photo by Ghadi TV

06 | Decision-Making in Contexts of Uncertainty



Photo by Genevieve French, Greenpeace

Decision-Making in Contexts of Uncertainty

In some contexts, city officials may not have access to climate data that enables them to know for certain how current or future climate change will impact their city.

This section outlines some options that city officials can take if you are not able to conduct a CRA due to lack of data or lack of technical experts to conduct a CRA.

Even without accurate data, you can still make investments in infrastructure to promote climate change resilience.



Garissa, Kenya; Photo by Luis Tato, AFP

Decision-Making in Contexts of Uncertainty

If you do not have accurate CRA data, you should reflect on two critical points:



What are the general climate hazards that impact my city now? For example, heavy rainfall, flooding, heat waves, etc.



How do these hazards impact different groups of people, especially vulnerable groups, neighbourhoods and economic sectors?



Bagerghat; Photo by World Bank

Decision-Making in Contexts of Uncertainty

You can safely make two assumptions, even without the data to back it up:



Existing climate hazards will become more frequent and more severe over time.



Climate risks will continue to affect vulnerable and marginalized groups and areas in your city as these risks become more severe in the years ahead.

You can therefore plan to invest in infrastructure or services that address current climate risks for vulnerable groups.



Barguna; Photo by Rafiqul Islam Montu, DownToEarth

Decision-Making in Contexts of Uncertainty



No Regrets investments



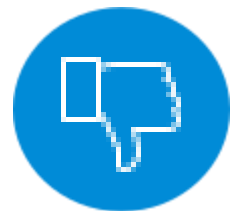
Low Regrets investments



Win-Win investments



Flexible & Adaptive investments



Investments that Avoid Maladaptation

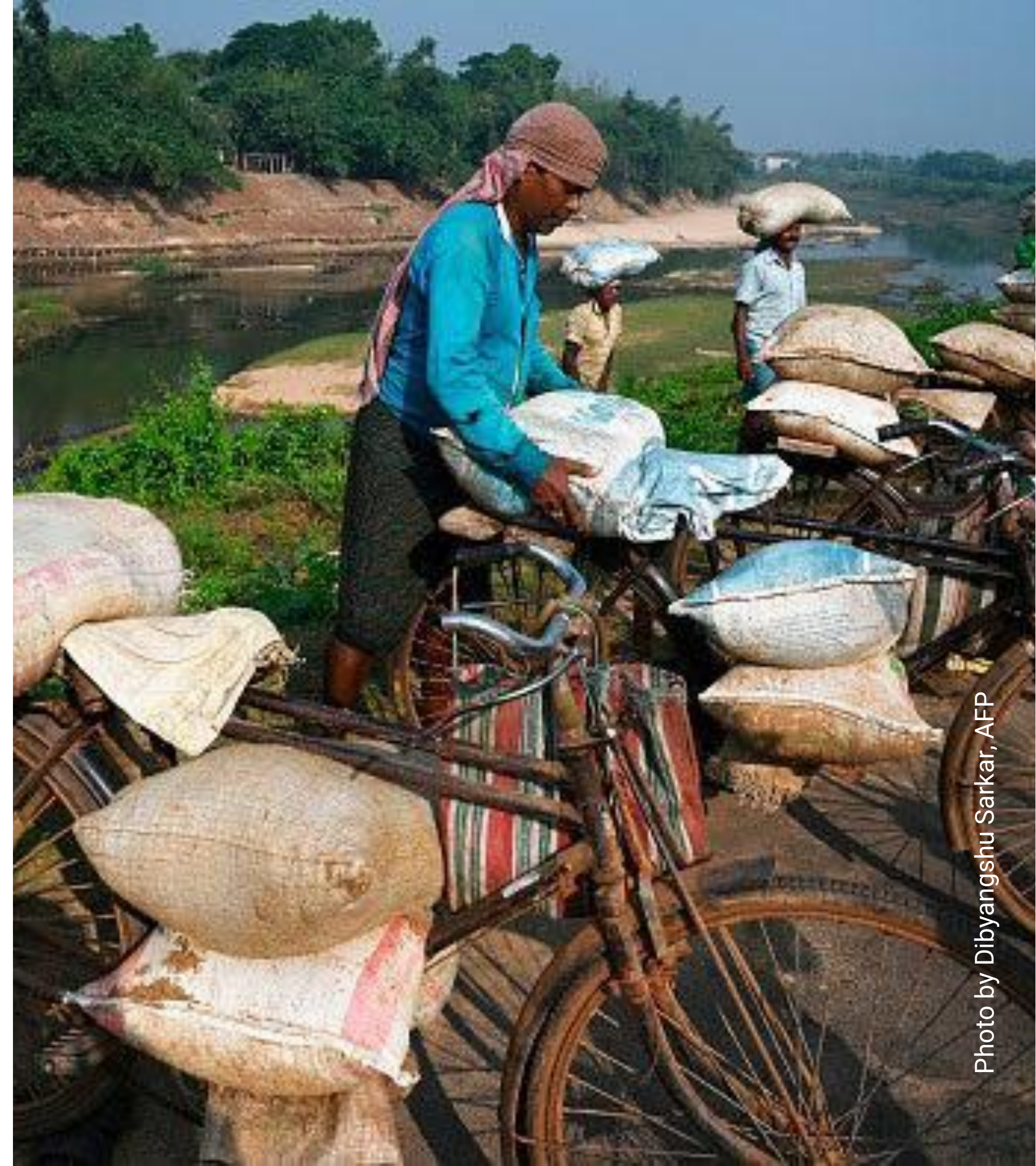


Photo by Dibyangshu Sarkar, AFP

Option 01 | No Regrets Investments



No Regrets investments are measures that deliver benefits that exceed their costs, regardless of whether climate risks turn out to be mild or severe in the future.

In contexts of uncertain data on current or future climate risks, city officials can comfortably make no regrets investments because they will provide benefits to cities no matter what impact climate change has in the future.

Examples of no regret investments include investing in water conservation measures in water constrained areas, investing in public housing for vulnerable groups, investing in climate data collection systems, and climate-proofing energy transmission infrastructure so that people have reliable access to electricity.



Photo by Gowtham AGM, Pexels

Option 01 | No Regrets Investments



Case Study | Wajir Solar Farms

Wajir experiences semi-arid climate with an average annual temperature of 28°C and rainfall varying from 250mm to 700mm. Climate change has led to extreme temperatures in the dry season and heavier rainfall in the wet season triggering prolonged drought and floods. These have intensified resource conflicts among pastoral communities over limited water and pasture, exacerbating the loss of livelihoods, livestock, and human lives.

The County government of Wajir has invested in a series of climate adaptation projects including installation of hybrid solar systems at boreholes; installation of hybrid solar systems and drip irrigation for community farms; and construction of water infrastructure such as livestock watering troughs and water kiosks, water storage infrastructure and piping.

These initiatives are considered no-regrets investments because they supply water for both domestic and livestock needs while also enabling irrigation-based agriculture in the semi-arid region. Tapping into abundant solar energy to power water systems, health centres and county offices offers an environmentally friendly solution that reduces reliance on fossil fuels and lowers cost of production.



Option 02 | Low Regrets Investments



Low Regrets investments are low-cost measures with potentially large benefits for building resilience under future climate change scenarios.

The name 'low regrets' implies that even if future climate risks are less severe than predicted, a city will have little regret from spending a bit extra on infrastructure investments to ensure they are resilient – versus the higher regret they would feel if they did not make the investment and climate risks turned out to be high in the future.

An example of a low regret investment is designing drainage systems to have higher piping capacity (e.g. by making drainpipes wider) in case future extreme rainfall events increase in intensity. The extra investment on wider pipes will be less regrettable than if a city faces a serious flood in the future.



Photo by Maksim Safaniuk, Getty Images (licensed via Canva)

Option 02 | Low Regrets Investments



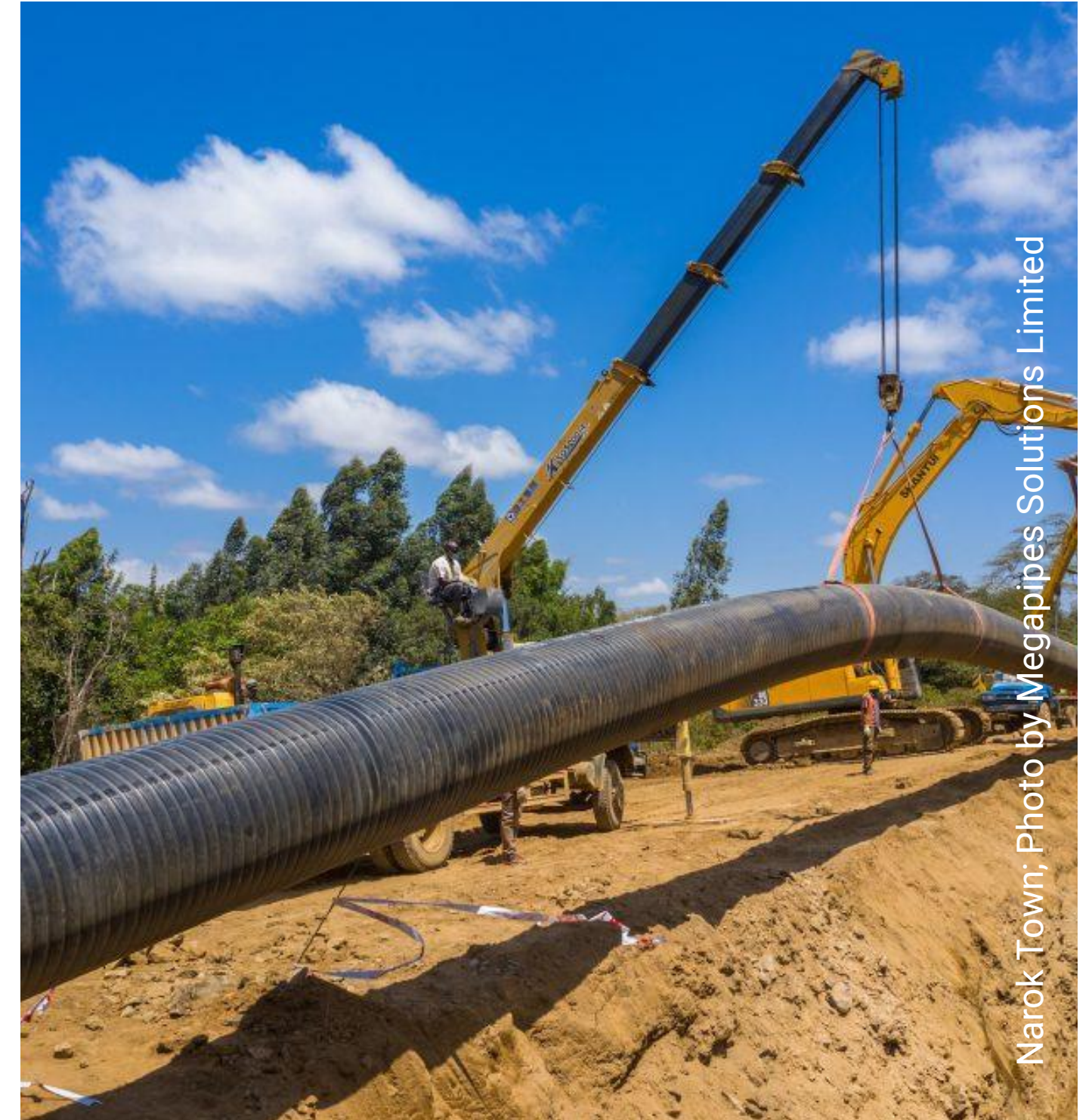
Case Study | Narok drainage system expansion

Narok town is geographically located in a 'basin' terrain and has experienced devastating flash floods during heavy rains since 1992.

In 2015 the town's drainage channels were rehabilitated and widened to open waterways that diverted water from its main course leading to flooding and loss of lives and property.

As a lasting solution, the municipality undertook additional expansion of the drainage channels to enable them to carry a bigger volume of water.

The widening of the drainage channels has reduced flooding in Narok.



Option 03 | Win-Win Investments



Win-win investments contribute to climate adaptation while also delivering other benefits to people or society.

In contexts with low data on climate risks, city officials can consider making win-win investments that potentially provide resilience benefits and also provide benefits that improve general quality of living in their city.

An example of a win-win investments is expanding public parks and green spaces in cities. Nature-based solutions like public parks help improve urban air quality and can minimize water runoff that would cause urban floods during high rainfall events. But in addition to climate resilience benefits, they also improve the physical and mental wellbeing of citizens by providing access to recreation and nature, making them a win-win.



Bahadur Shah Park; Photo by Bellayet Hossain, Wikipedia

Option 03 | Win-Win Investments



Case Study | Reclamation of Kibarani Dumpsite | Mombasa

The 50-year old Kibarani dumpsite occupied 12 acres of land in a strategic area of Makupa causeway along the Indian ocean (adjacent to Kenya Ports Authority harbour). The heaps of waste posed danger to marine ecosystem and human health.

In 2020, Mombasa city successfully reclaimed Kibarani dumpsite for a public recreational park through partnership with local private sector stakeholders.

The rehabilitation was undertaken through greening and installation of recreational facilities. Ecological restoration of the site involved planting more than 2,000 mangrove trees, sisal and coconut palms along the ocean (nature-based solutions)

Work on the park is ongoing, as it continues serving as a recreational space for Mombasa residents. It is anticipated to create a green, shaded area providing residents with a cool environment to reduce heat stress in the hot and humid coastal city.



Transformed Kibarani Dumpsite; Photo by Chadi TV

Option 04 | Flexible & Adaptive Investments



Flexible & Adaptive investments are infrastructure investments which can be updated on an ongoing basis to reduce climate risks as new data on climate risks emerge.

These investments follow the principle of **adaptive management** – keeping options open for the future, regularly monitoring changes and making updates as required.

City officials working without CRA data can use this approach to make investments in climate resilient infrastructure that have the design flexibility to be upgraded in the future, when the need for specific resilience measures is less uncertain.

Example: Flood protection measures in ports which allow for future increases in storm surge defense height by building foundations fatter now, but do not build higher defenses immediately while the extent of future flood risk is still uncertain.



Photo by AP

Option 04 | Flexible & Adaptive Investments



Case Study | Rumuruti Town, Laikipia

Laikipia County Government recently deployed slam dam technology in the flood-prone Rumuruti town to mitigate against flooding during heavy rains.

The slam dam is a portable and compact solution for flood defense. It is easy to install and provides a 100-150m flood barricade with a capacity of holding 8000 liters of water.

It is made of highly flexible EPDM material, making it adaptable to various surfaces, including uneven terrains. The tubes serve as barriers to redirect floodwaters and prevent overflows

By adopting this technology, Laikipia county has avoided severe impacts of floods and managed to collect and store over 500,000 liters of water. This has fortified flood resilience and provided opportunity to harness flood water for agricultural productivity.

Slam dams can be augmented through additional purchase on need basis, depending on anticipated flood risks.



Option 05 | Investments to Avoid Maladaptation



Maladaptive actions are those that attempt to address climate adaptation, but which will actually make it more difficult to cope with climate change risks in the future.

Maladaptation is the opposite of adaptation. Rather than making people, infrastructure, economic activity or governance more equipped to deal with future climate change, it makes them less able to deal with climate change and will mean that impacts will be more severe.

City officials should think about the potential consequences of their current investments under different potential climate futures and avoid maladaptive investments.

Examples of maladaptation include constructing infrastructure in potential flood risk areas or designing buildings without water conservation technologies in drought-prone areas.

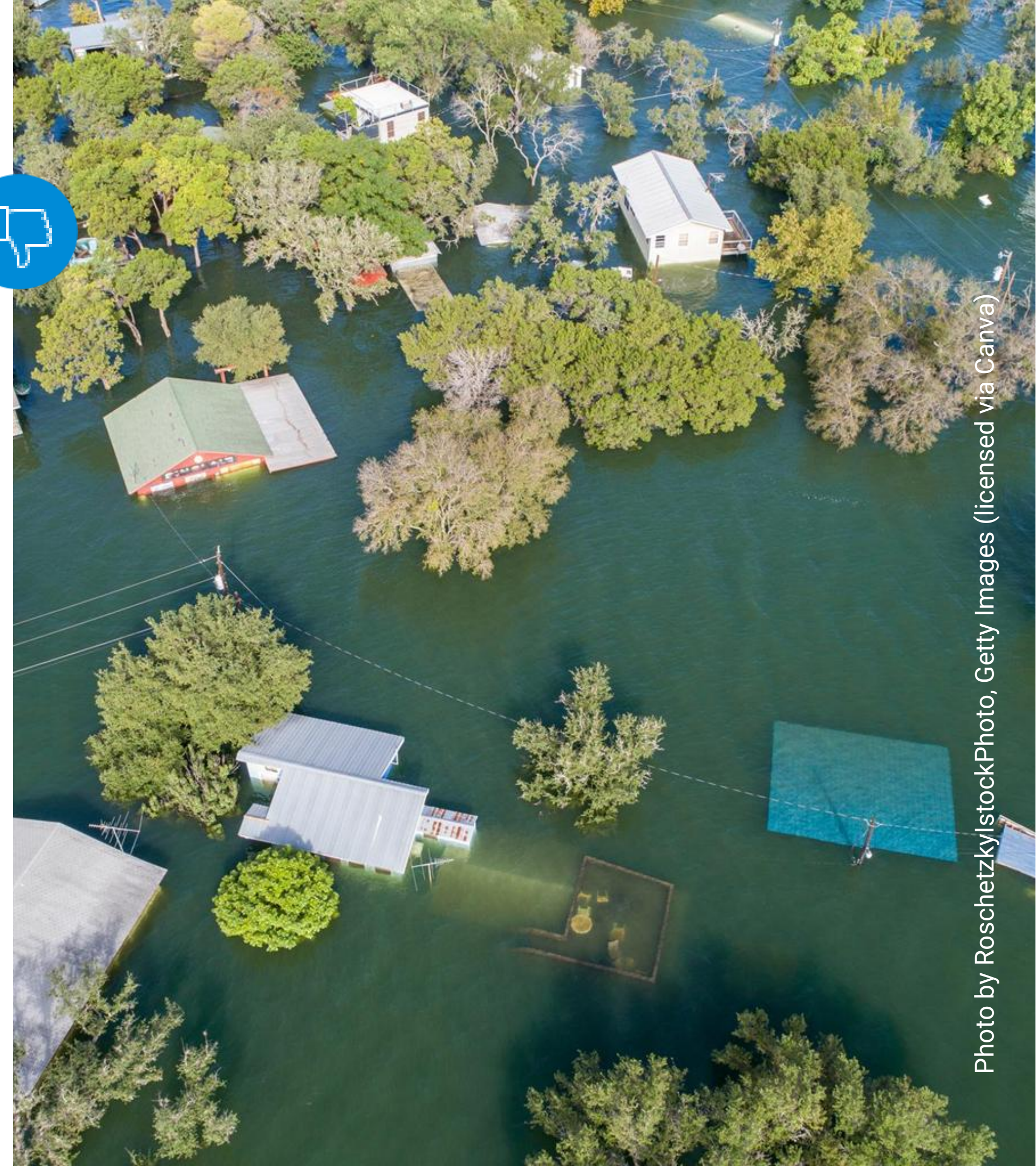
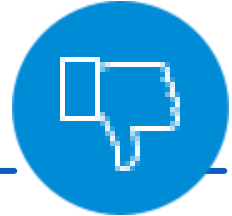


Photo by RoschetzkyStockPhoto, Getty Images (licensed via Canva)

Option 05 | Investments that Avoid Maladaptation



Case Study | The Nairobi Dam

The Nairobi dam was constructed in the early 1950s to serve as a water supply reservoir for Nairobi city, storing water flows from the Ngong River and the Rift Valley escarpment.

However, the dam's neglect has led to severe degradation, partial collapse, and encroachment by human settlements, thus posing serious health risks to both humans and the ecosystem. The reservoir is heavily polluted from untreated waste, including industrial effluents and sewage, which contaminates clean upstream water from Ngong Forest and degrades the water quality of downstream flows. This pollution has not only compromised water quality but has also resulted in the loss of biodiversity and the spread of water- and vector-borne diseases.

Since the dam is overgrown and unusable, it has lost its capacity to buffer against extreme water shortages during dry seasons and worsened flooding during heavy rains, thereby undermining the resilience of the large urban areas. This case highlights an example of how a lack of operation & maintenance to upgrade ageing infrastructure can lead to maladaptation.



Part of the Nairobi dam. Photo by The Star Newspaper

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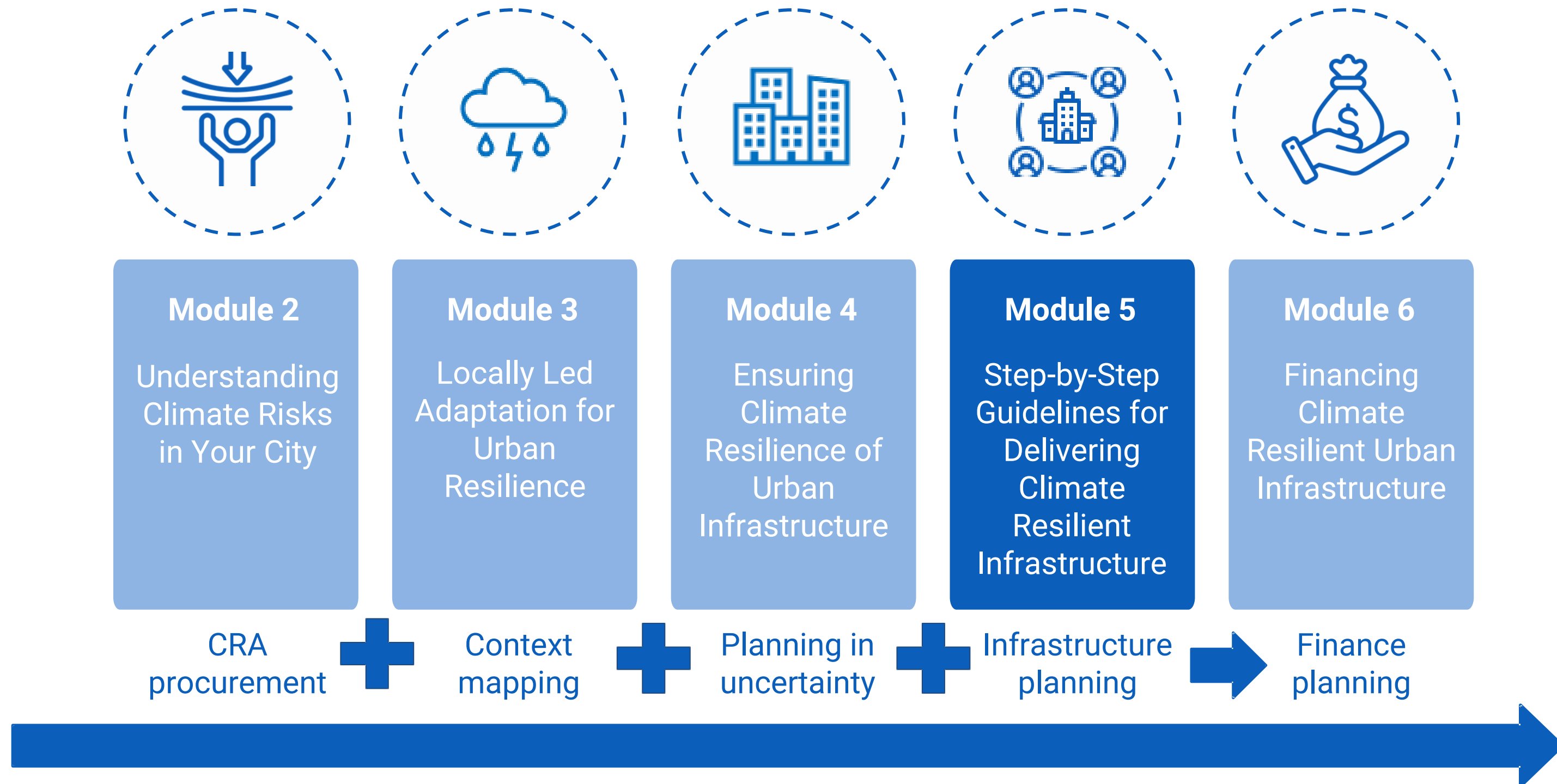
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- Nairobi, Photo by N. N. N., Getty Images (licensed via Canva)

07 | Interactive Exercise



Photo by Aroax from Getty Images (licensed via Canva)

Start Your Journey



The interactive exercises build on one another to link the content and support your understanding of the process to create adaptive and resilient infrastructure.

Infrastructure Plan Canvas

The infrastructure plan canvas helps to make ideas granular whilst bringing in considerations around adaptation, equity & inclusion, and climate risk.

→ **Strategy:** Use your mission from the context map combined with ideas you may get from a CRA to write a short strategy for your mission. You may also think about linking it to any local or national policies.

→ **Options:** What are the options for infrastructure (reflecting on Module 4) that you could use to achieve your strategy?

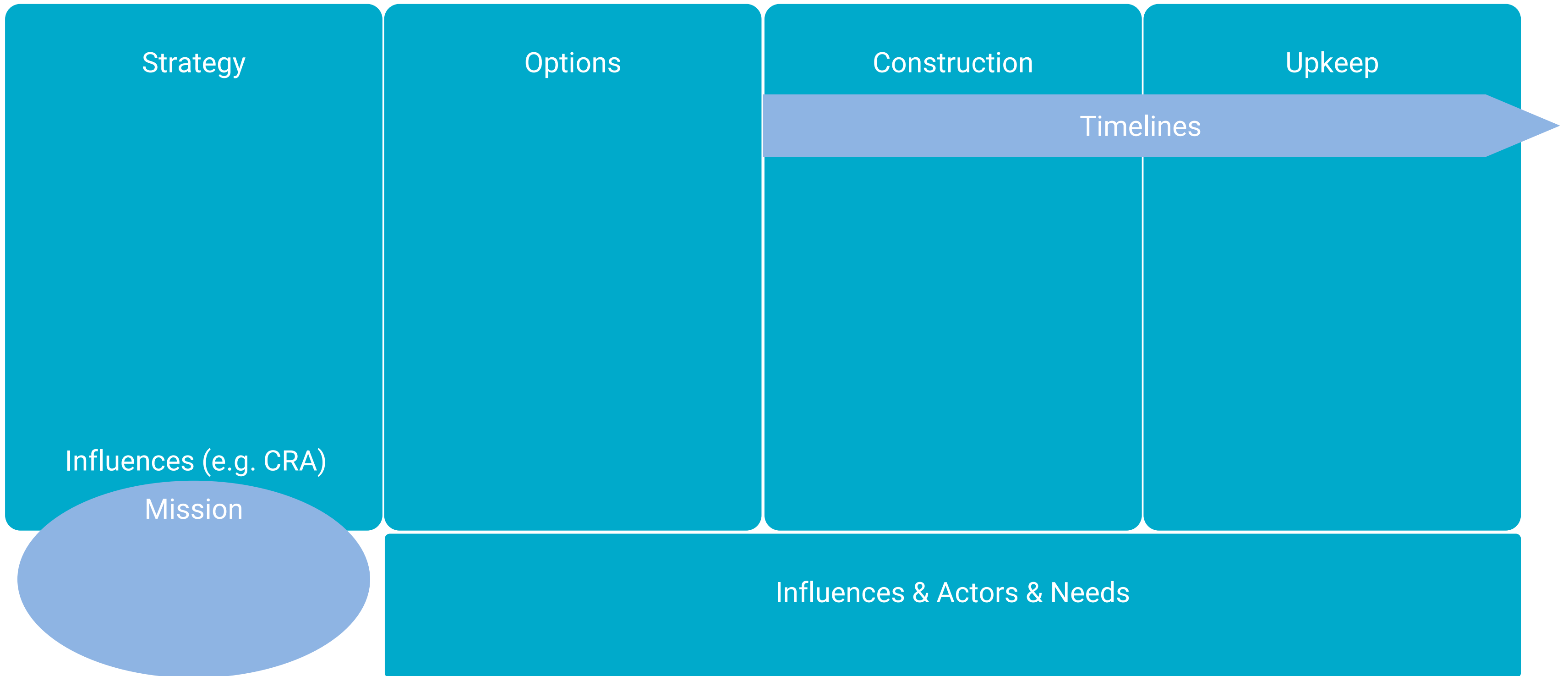
→ **Construction:** Who would construct it, where, and with what resources? Consider equity & inclusion for the chosen option.

→ **Timeline:** When would construction start, and what is the lifetime of this infrastructure?

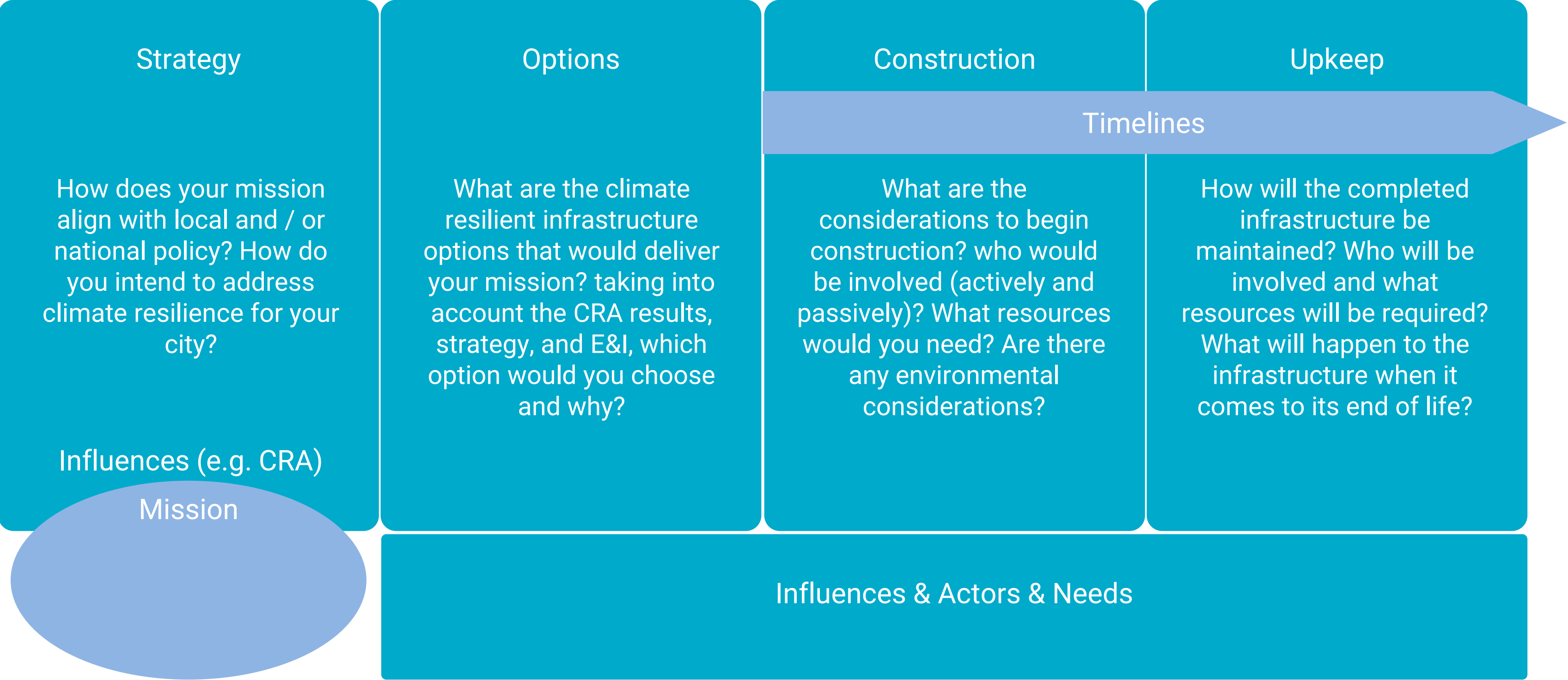


Dhaka City Skyline; Photo by Md Maruf Hassan, Getty Images (licensed via Canva)

Infrastructure Plan



Infrastructure Plan



Discussion

Share Your Infrastructure Plan

- 
- Does your strategy explain the different entry points for integrating climate resilience into city plans, policies and investments?
 - Can you explain how your chosen infrastructure investments moves beyond business as usual to build climate resilience?
 - How did you make decisions on what type of resilient infrastructure to build in situations where you do not have reliable climate risk data?
 - How do you ensure equity for those involved with, benefiting from, and living near the infrastructure?



08 | Summary



Summary

Congratulations on completing Module 5: Step-by-Step Guidelines for Delivering Climate Resilient Infrastructure!



Module 1

Introduction to
Climate
Change and
Urban
Resilience



Module 2

Understanding
Climate Risks
in Your City



Module 3

Locally Led
Adaptation for
Urban
Resilience



Module 4

Ensuring
Climate
Resilience of
Urban
Infrastructure



Module 5

Step-by-Step
Guidelines for
Delivering
Climate
Resilient
Infrastructure



Module 6

Financing
Climate
Resilient Urban
Infrastructure

The next module in the UCRMC is **Module 6: Financing Climate Resilient Infrastructure.**



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