URBAN HEAT RISK MANAGEMENT

RESOURCE PACKAGE

Consultative Version

January 2025

MCR 2030 Making Cities Resilient

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For additional information, please contact:

MCR2030 Global Secretariat
United Nations Office for Disaster Risk Reduction (UNDRR)
Global Education and Training Institute (GETI)
4F G-Tower 175 Art Center Dae-ro, Yeonsu-gu,
Incheon 22004, Republic of Korea
mcr2030-global@un.org

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Lead Authors: Holly Schofield (consultant) and Rohil Sabherwal (UNDRR intern)

Project Coordinators and Contributing Authors: Mutarika Pruksapong and Sanjaya Bhatia, UNDRR Global Education and Training Institute.

MCR2030 Regional Secretariats for the collection of case examples and coordination of city interviews**:** Isabel Njihia, UNDRR Regional Office for Africa; Adriana Campelo, Clément Da Cruz, Cristobal Lopez Maciel, Daniel Rodrigo Arteaga Galarza, and Ines Koch (intern), UNDRR Regional Office for the Americas and the Caribbean; Elaf Shoukr, UNDRR Regional Office for Arab States; Sunisa Soodrak, UNDRR Regional Office for Asia and the Pacific; and Yigyeong Oh, UNDRR Regional Office for Europe and Central Asia.

Peer-reviewers: MCR2030 Core Partners – Asian Development Bank (ADB); C40 Cities; ICLEI – Local Governments for Sustainability; International Federation of Red Cross and Red Crescent Societies (IFRC); Japan International Cooperation Agency (JICA); Resilient Cities Network (R-Cities); United Cities and Local Governments (UCLG); United Nations Development Programme (UNDP); United Nations Human Settlements Programme (UN-HABITAT); United Nations Office for Project Services (UNOPS); The World Bank Group; and World Council on City Data (WCCD).

Local government officials providing insights to the case studies:

- **Amadora, Portugal**: Luis Carvalho, Commander of Civil Protection Municipal Service
- **Incheon, Republic of Korea:** An Sung-Ah, Deputy Director
- **Quito, Ecuador:** Patricia Carrillo, Metropolitan Director of Risk Management
- **Cape Town, South Africa:** Amy Davison, Head of Climate Change
- **Nairobi, Kenya:** Grace Ojiayo, Assistant Director of Climate Change and Humphrey Otieno, Project Coordinator of Safer Nairobi Initiative

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TABLE OF CONTENTS

Foreword

Kamal Kishore

Special Representative of the UN Secretary-General for Disaster Risk Reduction,
Head of the United Nations Office for Disaster Risk Reduction (UNDRR)
and Co-Chair of MCR2030

Gino Van Begin

Secretary-General of ICLEI - Local Governments for Sustainability
and Co-Chair of MCR2030

Year after year, cities around the world face increasing risks from extreme heat events driven by climate change. Urban areas, with their dense populations and critical infrastructure, are particularly vulnerable to the escalating threats posed by rising temperatures and heatwaves due to the urban heat island effect, which makes metropolitan areas warmer than their surrounding countryside.

With 2024 on track to be the hottest year on record, surpassing 2023, an alarming trend of steadily rising global temperatures signals that urban heat risks will only continue to intensify. In recognition of the urgency of managing heat risks amid the escalating climate crisis, the United Nations Secretary-General issued a Call to Action on Extreme Heat in June 2024, addressing the immediate need to “heat-proof” societies while also protecting at-risk populations who are disproportionately affected by extreme climate events and disasters.

Given that an estimated 68% of the world’s population is expected to reside in cities by 2050, increasingly frequent and prolonged periods of extreme heat threaten to put millions of lives and the world’s economic output at risk. As cities continue to grow and climate risks intensify, the need for effective urban heat risk management has never been more urgent.

This Urban Heat Risk Management Resource Package aims to provide local governments with insights, examples of best practices, and the tools necessary to understand, mitigate, and manage the threats posed by urban heat. It focuses both on rethinking long-term urban design and planning and preparing for immediate heat risk response. Drawing on the experiences of cities around the world, this package not only underscores the importance of integrating heat risk management into local governance and planning frameworks but also emphasizes the critical role that national governments can play in supporting their subnational counterparts in these efforts.

This information package would not have been possible without the collective efforts of the Making Cities Resilient 2030 (MCR2030) Core Partners. As members of the MCR2030 Global Coordinating Committee, we strive to provide relevant and practical guidance to local governments, helping them identify a pathway to resilience in the face of disasters, climate change, and rapid urbanization. We are deeply grateful for the commitment and collaboration of all MCR2030 cities and partners as we continue to navigate the emerging challenges cities face in an increasing volatile climate. We hope it will be useful to cities and governments around the world.

EXECUTIVE SUMMARY

Extreme heat events are becoming more frequent and severe due to accelerating climate change, with 2024 poised to become the hottest year on record. Global temperatures have steadily risen over recent decades, driven by greenhouse gas emissions, bringing the planet dangerously close to the 1.5°C threshold identified as critical for avoiding the most catastrophic impacts[1] of the climate crisis. These rising temperatures pose significant risks, especially in urban areas where heat stress exacerbates health, social, and economic challenges. Prolonged exposure to extreme heat, particularly temperatures above 35°C, can lead to severe health crises and even death, while globally threatening the productivity of billions of workers.

Urban centres are particularly vulnerable due to the Urban Heat Island (UHI) effect, which intensifies heat exposure in metropolitan areas through factors such as reduced green spaces, heat-absorbing infrastructure, and waste heat from human activity. As cities grow, with an estimated 68% of the global population expected to live in urban areas by 2050[2], these risks will disproportionately impact vulnerable populations, including those in poverty, women, children, and the elderly. With some cities projected to face over 150 days annually of temperatures above 35°C at just 1.5°C of warming[3], the need for action to mitigate urban heat is urgent.

Multi-sectoral collaboration is crucial to address these challenges effectively, Local governments are central to these efforts, leveraging their role in urban planning, public health, and emergency response to implement heat-resilient strategies. By fostering cross-sectoral collaboration and focusing on equitable solutions, municipalities can integrate green infrastructure, early warning systems, public-private partnerships and public awareness campaigns into their Heat Action Plans.

This urban heat risk management resource package synthesizes insights from over 30 global case studies and deep-dives into five cities—Amadora (Portugal), Incheon (Republic of Korea), Quito (Ecuador), Cape Town (South Africa), and Nairobi (Kenya). Through interviews and extensive literature reviews, this report identifies governance structures, best practices, and challenges in managing urban heat. It also provides a series of recommendations useful for both local and national governments in developing targeted, effective, and sustainable strategies for mitigating urban heat risks.

Summary of Key Findings and Recommendations for Local Governments

- **Conduct a City Baseline Heat Risk Assessment and Mapping –** Conducting a heat or climate baseline assessment is crucial for understanding urban heat risks and vulnerabilities. By partnering with academic institutions and other national and international organizations, cities can collect and analyse data to efficiently allocate resources and plan strategic interventions.
- **Set Clear Heat-Planning Goals and Metrics –** Cities should define measurable and actionable goals based on baseline assessments, ensuring they address specific community needs. These targets can include metrics like green space per resident or canopy coverage, adjusted for citywide or neighbourhood contexts.

[1] United Nations (2024). Secretary-General's Press Conference on Extreme Heat. https://www.un.org/sg/en/content/sg/press-encounter/2024-07-25/secretary-generals-press-conference-extreme-heat

[2] UN-DESA (2018). 68% of the world population projected to live in urban areas by 2050, says UN. https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html

[3] Mackres, E., Wong, T., Null, S., Campos, R. and Mehrotra, S. (2023). The Future of Extreme Heat in Cities: What we Know – and What We Don't. https://www.wri.org/insights/future-extreme-heat-cities-data

- **Develop a Comprehensive Heat Action Plan and Integrate into Long-Term Urban Planning –** A Heat Action Plan consolidates efforts across sectors, linking heat risk mitigation to broader urban policies. It should include detailed frameworks for implementation including a mixture of solutions focusing on long-term anticipatory actions such as adjustments to urban design and regulations, use of cooling materials, green infrastructure, green space, and shading as well as effective response mechanisms including heat risk early warning systems. The Heat Action Plan should include regular progress monitoring and evaluations.
- **Ensure Cooling Solutions are Sustainable and Climate Friendly –** Focus on nature-based and passive cooling techniques to minimize climate impacts. Retrofitting urban environments with energy-efficient cooling systems ensures sustainable and effective heat mitigation.
- **Establish a Heat Alert System –** Implement a tiered alert system to inform the public about heat risks and reduce strain on healthcare facilities. Supplement alerts with actionable advice for at-risk populations to enhance their resilience. These alerts should be an integral part of the city's Heat Action Plan to ensure public safety during extreme heat events.
- **Harness Political Leadership –** Political leadership is key to driving action, aligning stakeholders, and securing resources. Engaging leaders with evidence of urban heat's impacts and co-benefits of action fosters commitment and long-term support.
- **Establish a Dedicated Focal Point for Heat Risk Management and Strengthen Coordination Across Essential City Systems –** Appointing a dedicated focal point ensures the efficient implementation of the Heat Action Plan, drives collaboration and ensures accountability and effective coordination across departments. This can support the effective implementation of cross-sectoral heat resilience strategies and ensure various interventions contribute to city-wide heat risk reduction goals.
- **Build Awareness on Heat Risk Reduction at All Levels of Society –** Education and outreach programs can improve understanding of heat risks among both officials and citizens. These efforts enable communities to protect themselves while leveraging city resources for heat mitigation effectively.
- **Engage All Relevant Stakeholders and Leverage Public Engagement –** Involve city departments, private sector actors, and civil society organizations in the design and implementation of cooling solutions. Broad collaboration ensures comprehensive and sustainable heat risk management strategies. Engage low-income and marginalized communities in participatory planning processes to address inequities in cooling access. Public engagement ensures initiatives reflect actual needs and fosters innovation through community-led solutions.
- **Strengthen Partnerships to Enhance Heat Risk Management –** Form diverse partnerships including with local, national, and international organizations to access resources, expertise, and funding. Sharing experience and learning from other local governments facing similar challenges on heat risk management is beneficial. Leveraging these collaborations brings innovative solutions and global visibility to urban heat initiatives.
- **Leverage Public-Private Partnerships** – Actively seek and foster partnerships with private sector stakeholders to enhance urban heat resilience. By creating clear legal frameworks, providing investment incentives, and building the capacity to coordinate these collaborations, cities can access critical resources, innovative solutions, and technical expertise.

- **Seek Diverse and Sustainable Financing for Heat Management –** Develop varied financing strategies, including green bonds, public-private partnerships, and international grants. Dedicated budgets and incentives for green infrastructure create a solid foundation for addressing urban heat.
- **Build Local Technical Capacities –** Investing in ongoing capacity building including training programs for government officials, urban planners and architects, community leaders, and emergency responders is essential for equipping stakeholders with the skills, knowledge, and tools they need to manage urban heat risks. Collaboration with academic institutions is also beneficial.

Recommendations for National Governments

- **Conduct Heat Risk Mapping –** National governments should develop detailed heat risk maps, combining data on vulnerability and heat hotspots, to identify the most at-risk populations and geographic areas affected by rising temperatures. Heat risk mapping allows governments to have a better understanding of heat risks and their implications, hence facilitating more proactive and informed action.
- **Develop Heat Risk Management Strategies and Heat Action Plans –** National governments should seek to develop detailed heat risk management strategies and Heat Action Plans, emphasizing heat risk as a key priority in national climate policies and National Adaptation Plans (NAPs) to ensure alignment with broader adaptation goals. A strong Heat Action Plan should be developed, outlining targeted interventions the resources needed to achieve them, and frameworks for collaboration among the different sectors and levels of government.
- **Provide Supportive Legal Frameworks and Guidelines for Localizing Heat Risk Management Implementation –** Local governments play a key role in heat risk management, but they need clear legal and policy support to act effectively. The effective localization of heat risk management strategies depends on national governments providing the necessary support to align local actions with broader national policies and ensure coordinated responses. Guidelines providing actionable steps, best practices, and resources tailored to the unique needs of municipalities is crucial.
- **Revisit Existing Building Codes and Land Use Planning –** National governments should review and update building codes and land use policies to ensure they support environmentally friendly cooling solutions and address the challenges of rising urban heat. Building codes should incorporate requirements for heat-resilient infrastructure, and land use planning guidelines should promote heat-sensitive urban design, including strategies like urban greening, shading, and improved street layouts to enhance airflow and reduce heat buildup. Setting national minimum standards for heat-resilient building codes and land use planning can facilitate similar or greater action at the local level.
- **Embed Heat Risk in Multi-Hazard Early Warning Systems –** National governments should establish heat indicators and develop a system to trigger warnings during periods of high heat risk. These systems should include guidelines on anticipatory actions, ensuring communities, local governments, and emergency services are prepared to respond rapidly to minimize health risks and disruptions. By embedding heat risk into broader warning frameworks, governments can ensure a comprehensive and coordinated approach to managing multiple hazards, enhancing resilience and reducing the worst effects of extreme heat.

- **Strengthen Financial Support –** A defined and coordinated national approach to financing urban heat risk management is essential, given the cross-regional nature of heat risks and their impact on multiple sectors. This could include creating dedicated funding streams or integrating heat risk management into existing budgets for sectors like urban planning, environmental management, public health, and disaster risk management. A national approach to fundraising, such as accessing international climate funds, issuing green bonds, or fostering public-private partnerships, can provide additional resources to support more large-scale interventions and will help local governments implement sustainable and impactful heat solutions.
- **Provide Continued Capacity Development Support -** Recognising the importance of specific and technical skills for urban heat risk management across sectors, national governments should support the creation of training programs and curriculums tailored to the needs of key stakeholders, including local government officials, urban planners, architects, community leaders, and emergency responders. These programs should focus on practical solutions, the latest technologies, and best practices for managing heat risks, ensuring stakeholders are well-prepared and up to date.
- **Actively Support Experience Sharing and Co-creating of Solutions –** National governments should support exchanges between national and local governments, between different local governments, and with other countries both regionally and internationally. These exchanges help share best practices, identify lessons learned, and support the development of tailored solutions to address specific needs.

Introduction

The increasing frequency and severity of extreme heat events have highlighted the urgent need for coordinated global and local action. According to the European Union's climate change service Copernicus, summer 2024 in the Northern Hemisphere, specifically the months of June, July, and August, was the planet's hottest such period on record. Temperatures during the summer were 0.69°C higher than the 1991 to 2020 average, putting 2024 on track to also be the hottest calendar year on record (Paddisons, 2024).

This fits into an alarming trend of rising global temperatures such that record-breaking heat has increasingly become the new norm. Driven primarily by anthropogenic climate change and greenhouse gas emissions, each of the past four decades have been warmer than the one preceding it, with the last nine years since 2014 being the nine warmest years yet. Despite the record-breaking warmth of 2023—the hottest calendar year on record, with NASA scientists reporting global average temperatures to be 1.36°C above preindustrial levels and dangerously close to the 1.5°C threshold set by the Paris Agreement—2024 now appears almost certain to surpass this milestone (Zhong, 2024). According to the World Meteorological Organization (WMO), global near-surface temperatures in 2024 have already exceeded those of 2023, putting it on track to become the warmest year ever recorded. This trend demonstrates the accelerating reality of the climate crisis, with global temperatures nearing the critical 1.5°C limit identified as essential for avoiding the most catastrophic climate impacts (WMO, 2024).

The impacts of such extreme heat on society are deadly and threaten to only worsen with warming trends. Prolonged exposure to high temperatures, especially those greater than 35°C, can quickly and catastrophically escalate, for in extreme cases, even after as little as 10 to 20 minutes the body's ability cool to itself can become impaired, heat exhaustion can kick in, and major organs can begin to shut down. Therefore, as everyday temperatures continue to rise, heightened heat stress has turned some ordinary activities deadly. As seen during heatwaves in 2024, individuals have succumbed to heat stroke during outdoor events like concerts or while engaging in simple recreational activities like hiking (Zeris, 2024). Between 2000 and 2019, models estimate that around **489,000 heat-related mortalities occurred each year**. From an economic productivity standpoint, extreme heat conditions currently **threaten 2.41 billion workers or 70% of the planet's working population** (UN, 2024).

In recognition of this alarming trend and the urgent, life-threatening risks posed by extreme heat, in June 2024, the United Nations Secretary-General issued a **Call to Action on Extreme Heat**, emphasizing that extreme heat is among the deadliest impacts of climate change and calling on governments, cities, and communities to adopt bold measures to protect vulnerable populations and build heat resilience (UN 2024). The call reflects the immediate need to address the multifaceted dangers of extreme heat, which are already being felt worldwide.

The effects of rising temperatures and extreme heat are most acutely felt in urban centres. On average, cities are up to 7°C warmer than their surrounding countryside during the daytime and can still be up to 5°C warmer at night (Gregory, 2021). This phenomenon, wherein metropolitan areas are warmer than their rural surroundings, is known as the **urban heat island effect (UHI)**. It is the result of several interrelated factors including but not limited to:

- **Urban Canyons:** reduced ventilation, wind blocking, and heat trapping caused by the close proximity of tall compact buildings;
- **Urban Deserts:** diminished blue spaces, green cover, and vegetation that often provide natural shade and cooling benefits;

- **Concrete Jungles/Thermal Inertia:** the use of heat-trapping materials like concrete and asphalt in large quantities;
- **Waste Heat:** heat generated by human activities like air conditioning, transport, and industrial processes.

City residents' increased exposure to extreme heat conditions, even in normal circumstances, means in turn that they are also more gravely threatened by the future risks posed by climate change and rising global temperatures. According to IPCC predictions, exacerbated by the UHI effect, with 1.5°C of warming, 67 cities will experience over 150 days a year of greater than 35°C temperatures. With 3°C of warming, that statistic rises to 197 cities (UN, 2024). Moreover, extreme heat does not affect all people equally with those living in poverty, children, women, and the elderly most acutely exposed to its dangers. Therefore, given UN predictions that by 2050 68% of the world's population will be living in cities, the hazardous conditions of the UHI effect are only increasingly more likely to capitulate into disasters (UN Habitat, 2022).

Local governments are crucial players in urban heat management because they are uniquely positioned to implement targeted, context-specific solutions and oversee critical aspects of urban planning and resource allocation. Their proximity to communities enables them to address local vulnerabilities effectively and tailor interventions to the specific needs of their populations.

This *Urban Heat Risk Management Resource Package* brings together insights from over 30 global case studies and detailed analyses of five cities—Amadora (Portugal), Incheon (Republic of Korea), Quito (Ecuador), Cape Town (South Africa), and Nairobi (Kenya). Drawing from interviews and extensive research, it highlights key governance structures, best practices, and challenges in tackling urban heat. The package offers clear, practical recommendations to help local and national governments create targeted, effective, and sustainable strategies to reduce urban heat risks.

Methodology

This ***Urban Heat Risk Management Resource Package*** was developed using a structured approach to collect insights from cities around the world. This included a thorough review of city-level case studies and targeted interviews with experts and officials from selected cities.

Literature Review and Analysis

The foundation of the resource package was a review of over 30 case studies (detailed in Annex 2). These studies offer valuable insights into best practices for managing urban heat risks, highlighting diverse strategies that are tailored to specific climatic, political, and developmental contexts. This analysis identified key barriers to urban cooling, including financial constraints, limited institutional capacity, and challenges in community engagement. By synthesizing lessons learned and successful examples, the review informed actionable recommendations and strategies for enhancing heat resilience across diverse urban environments.

Deep Dive City Case Studies

To deepen the understanding of urban heat risk management, five cities were selected for further study: Amadora (Portugal), Quito (Ecuador), Incheon (Republic of Korea), Cape Town (South Africa), and Nairobi (Kenya). These cities were chosen for their regional diversity and the willingness and availability of their governments to commit the time to participate.

Semi-structured interviews were conducted with officials and experts from city governments during October and November 2024. Interviews were conducted in English, except for that with representatives from Quito, which were conducted in Spanish, and lasted between 30 and 80 minutes though one city opted to provide written responses rather than participate in a live interview. These interviews explored several key areas:

- General urban heat risk management;
- Governance and institutional arrangements;
- Long-term heat risk reduction linked to urban design and planning measures and the implementation of nature-based solutions (e.g., parks, green corridors), including associated opportunities and challenges;
- Heat risk response and early warning mechanisms;
- Support and collaboration from internal and external stakeholders;
- Success factors, challenges, capacity building needs, recommendations, and future steps.

Detailed notes were taken during the interviews, supported by transcription software. The data collected from the semi-structured interviews was analysed to identify key themes and insights related to urban heat risk management. Information was extracted and grouped across the aforementioned focus areas, supported by additional secondary literature available on heat risk management in the interviewed cities. The analysis involved grouping responses to uncover common success factors, challenges, and opportunities, as well as city-specific strategies and recommendations. This approach ensured a comprehensive understanding of the data. It was then validated by sharing draft case studies with the respective cities for review and refinement.

Limitations

- **Language:** Interviews were conducted in English, except in Quito which was conducted in Spanish. This may have limited the depth of insights in non-English-speaking contexts, where language nuances could affect the accuracy of responses.
- **Time Constraints**: Interviews lasted between 30 and 80 minutes, with the longer interviews allowing for a more comprehensive exploration of complex or multifaceted issues. However, shorter interviews restricted the ability to delve deeply into nuanced perspectives, potentially resulting in a less detailed understanding of challenges or strategies.
- **Limits to Transcription Software**: Transcription software was initially employed to support notetaking during the interviews. However, it was often found to be less accurate than the manually taken notes and was limited to processing the English-language interviews.
- **Regional Representation:** The selected cities were chosen for their diversity, but some regions with significant heat risks, such as parts of South Asia or the Middle East, may not be fully represented.
- **Stakeholder Representation:** Urban heat risk management spans various departments within municipal governments, including environment, urban planning, public health, and disaster risk management, among others. While the interviews primarily focused on designated officials engaged in heat risk management who had a strong understanding of city-wide strategies and initiatives, the research would have benefited from the input of other municipal departments involved in addressing heat risks, but time restrictions made it impossible to include such perspectives from other departments.

Case Studies

This section presents five in-depth case studies, offering a detailed examination of urban heat risk management. Key focus areas include governance structures, institutional arrangements, anticipatory design adaptations, and responsive measures. These case studies highlight innovative approaches and practical strategies, providing insights into building urban heat resilience across diverse climatic, political, and socioeconomic contexts.

Case Study: Amadora

Executive Summary

Amadora, a densely populated urban municipality in the Lisbon Metropolitan Area, is increasingly vulnerable to extreme heat due to rising temperatures and the urban heat island effect. Over the past three decades, Amadora has experienced a significant increase in temperature, with projections indicating further rises by the end of the century. The city's strategies to combat these heat risks include the development of green spaces, early warning systems, and cross-sectoral collaboration between local government, academia, the private sector, and international bodies. Key lessons from Amadora's experience highlight the importance of ***leveraging strong political leadership***, ***establishing a dedicated focal point for heat risk management***, and ***institutionalising heat risk within broader climate adaptation efforts***.

Introduction and Context

Heatwaves are an increasingly critical issue in Portugal with extreme temperatures having severe impacts on both health and the environment. In 2022 alone a heatwave caused 2,212 deaths across the country. The main risks from heatwaves, as outlined in the National Risk Assessment, include impacts on the population, socioeconomic factors, and the environment. In urban areas, these impacts are exacerbated by high population and building densities. The removal of trees and vegetation reduces shading and evapotranspiration, while dark, impermeable surfaces absorb heat during the day and release it at night. Tall buildings and narrow streets limit wind flow, trapping heat at lower levels, and vehicles, factories, and air conditioners contribute to the emission of hot exhaust gases[4].

With a population of almost 200,000, Amadora—a densely populated urban municipality in the Lisbon Metropolitan Area—similarly faces significant challenges from rising temperatures and the increasing frequency of heatwaves. Of the past 30 years, 20 years recorded higher than average temperatures, and projections indicate an average temperature increase of 0.4°C by the end of the century. The urban heat island effect, exacerbated by the city's high population density and abundance of impermeable surfaces, further heightens the city's vulnerability. Other key drivers of heat exposure in addition to high population density also include limited capacity for green expansion and socioeconomic factors that impact energy efficiency and cooling accessibility[5]. Moreover, at-risk populations, such as the elderly and low-income households, are particularly threatened during these extreme heat events[6].

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[4] MCR2030. "Flames of Change: Innovating Heat and Wildfire Governance for Inclusive Communities," 28 March 2024. http://www.undrr.org/publication/flames-change-innovating-heat-and-wildfire-governance-inclusive-communities

[5] UNDRR (2022c). UN-led initiative recognizes city of Amadora as a Resilience Hub. https://www.undrr.org/news/un-led-initiative-recognizes-city-amadora-resilience-hub

[6] MCR2030. "Flames of Change: Innovating Heat and Wildfire Governance for Inclusive Communities," 28 March 2024. http://www.undrr.org/publication/flames-change-innovating-heat-and-wildfire-governance-inclusive-communities[56]

Governance and Institutional Arrangements

Amadora's approach to managing urban heat risk has evolved significantly, driven by rising temperatures, severe heatwave events, and targeted resilience-building initiatives. Following a severe 2003 heatwave, Amadora began recognising the need for heat preparedness, but it was only in 2010 that the city truly started to prioritise heat risk management. This shift was driven by Amadora's decision to join the *Making Cities Resilient Campaign*[7] that same year. The Campaign's approach required Amadora to complete a resilience scorecard assessment, identify resilience gaps, and develop a disaster risk reduction (DRR) plan to respond to them, which **highlighted urban heat as a significant risk and vulnerability for the city**. This process provided Amadora with a clear, systematic framework to evaluate climate risks, helping the city to integrate extreme heat considerations more fully into urban planning and policy.

Heat risk management in Amadora is a collaborative, structured effort driven by both political and operational leadership. The governance framework is supported by **strong political commitment from the Mayor** who provides high-level alignment and support across city departments, ensuring that heat risk management remains a priority. This political backing secures **stakeholder buy-in** and **embeds resilience goals across various city functions**, giving heat risk strategies essential visibility and driving collaborative planning and decision-making.

Civil Protection serves as the technical lead, acting as the focal point for the coordination and implementation of DRR strategies, which include climate change adaptation and urban heat risk measures. The department also manages the **municipal budget for heat risk**, with approximately €5 million allocated to Civil Protection and around €1 million dedicated to heat management activities including: expanding and maintaining green areas; conducting awareness sessions and distributing advocacy materials on measures to mitigate climate change impacts; supporting local clean energy projects; and recognizing initiatives and school projects through awards. While these funds have allowed the municipality to advance certain initiatives, this funding is recognised as insufficient for comprehensive risk management.

Several municipal departments contribute to heat risk reduction, namely:

- **Urban Planning Department**: integrates heat risk reduction into city design, incorporating green infrastructure and cooling elements to reduce urban heat effects;
- **Social Action Department**: supports at-risk groups, including the elderly and homeless, by conducting outreach and providing resources during heatwaves;
- **Environment Department**: enhances green spaces and natural cooling areas, supporting a holistic approach to heat risk reduction;
- The **Health Sector** is recognized as a key stakeholder for its potential to monitor public health impacts, coordinate health services, and support at-risk populations during heat events. While it has the capacity to provide critical data and guidance that could shape the city's heat response strategies, including extreme heat protocols, the city is working to fully integrate these functions.

Together, these departments form a cohesive, multi-agency approach to managing urban heat risk. Civil Protection consolidates information from each department to coordinate efforts effectively, ensuring that Amadora's heat risk strategies are as comprehensive and adaptive as possible.

[7] The Making Cities Resilient Campaign was launched in 2010 with a focus on raising awareness and commitment of local government leaders on disaster resilience. It was succeeded by the Making Cities Resilient 2030 (MCR2030 initiative) in 2021.

Support from the National Government

The national government's support for Amadora's heat risk management is mainly **indirect**, with direct assistance, such as designated funding or plans and policies specifically tailored for Amadora's needs, being limited. Instead, the national government's influence and resources flow through the Metropolitan Authority, which coordinates climate efforts across the 18 municipalities within the Lisbon Metropolitan Area, including Amadora, though it must compete or collaborate with neighbouring cities to shape these initiatives.

Amadora has a strong relationship with the Metropolitan Authority, which has implemented a Climate Change Adaptation Plan covering heatwaves and has funded local projects, such as the development of urban parks, benefiting Amadora and neighbouring cities. This regional structure enables valuable collaboration and shared resources, allowing Amadora to co-design projects that address both local and regional needs. However, it can sometimes slow Amadora's ability to address specific issues quickly, as resources and priorities are shared across the region rather than directly allocated to the city.

Stakeholder Involvement

Stakeholder involvement in Amadora's heat risk management involves contributions from the municipality, academia, the private sector, international organizations, NGOs, and civil society.

- The Municipality plays a crucial role by obtaining and consolidating essential data that enables Amadora to track, analyse, and respond effectively to heat risks. **Regular Working Group meetings** bring together city departments and stakeholders to coordinate on strategies, data-sharing requirements, and community needs.
- **Partnerships with academic institutions**, including the Universidade Nova de Lisboa, have been established to develop Amadora's climate profile, offering insights that inform climate adaptation and heat risk strategies. This collaboration strengthens Amadora's ability to base decisions and actions on reliable climate data and academic research.
- **Partnerships with private sector** companies like USendIt have been instrumental. USendIt, with facilities in Amadora, contributed technology and financial resources to develop the city's Early Warning System (EWS), which sends alerts to residents during heatwaves. This collaboration has strengthened Amadora's emergency communications and overall resilience infrastructure.
- Local communities and at-risk populations are essential stakeholders in Amadora's heat risk management. **Community engagement** is fostered through **participatory planning processes**, where residents contribute to identifying and implementing solutions. Key community partners, such as the Portuguese Red Cross, local fire department, and police, support Amadora's EWS by helping disseminate heatwave warnings and safety information to all residents, particularly vulnerable groups. These organizations provide on-the-ground support, ensuring risk communication is effective and inclusive.
- **Partnerships with international organisations**, such as UNDRR, and their subsequent participation in the *Making Cities Resilient Campaign* (and later *MCR2030*) provided valuable frameworks for assessing and managing heat risks. Through this engagement, Amadora completed a Scorecard[8] assessment that highlighted urban heat as a significant risk. Knowledge exchange with other participating cities in the United Kingdom, Italy, and

[8] Disaster Resilience Scorecard for cities. https://mcr2030.undrr.org/disaster-resilience-scorecard-cities

Sweden allowed Amadora to adopt diverse perspectives and improve its internal heat risk management practices.

Together, this collaborative network of stakeholders enhances Amadora's ability to manage heatwave risks, combining local knowledge, academic research, international insights, and technological support to create a community-centred approach to DRR.

Anticipatory Actions for Long-Term Heat Risk Reduction

While the city's awareness of urban heat as a critical risk has grown quickly in response to rising temperatures, long-term changes in urban design, building standards, infrastructure upgrades, and land use planning have been a slower process. This is due to a range of factors such as the complexity and high resource demands of larger-scale projects, lengthy regulatory processes, physical space limitations in dense areas, and the challenges of retrofitting existing infrastructure. Addressing immediate needs often takes priority, which can delay broader, structural adjustments. Increasing awareness of the full range of available solutions also takes time, as it involves adapting traditional practices and expanding knowledge and capacity around innovative, climate-resilient strategies.

Amadora has taken actions such as the **integration of urban planning with emergency and contingency planning** to ensure that development aligns with resilience goals[9]. These initiatives represent essential steps toward embedding heat risk reduction into the city's structural and strategic framework for sustainable urban resilience.

Additionally, Amadora has adopted nature-based solutions like the **creation of green corridors and urban parks** to enhance urban cooling and biodiversity. The city is also working on an ambitious tree-planting plan, aimed **at increasing green areas by 50% over the next five years**. This effort emphasizes community involvement, inviting residents to participate in the planning and implementation processes. Such a participatory approach not only enhances urban design but also raises public awareness about the importance of green infrastructure in managing heat risks and gives greater insights to the municipality about how urban heat is affecting people at the community level.

While nature-based solutions (NBS) provide improved cooling, enhanced biodiversity, and stronger community engagement, Amadora continues to face **obstacles in allocating space for greenery** within its dense urban environment. The city has emphasised the **urgent need to update building codes and improve building efficiency** to strengthen its long-term resilience to rising temperatures.

Heat Risk Response

Amadora has developed an EWS with private sector support from USendIt to inform residents about heatwave risks and promote public safety[10]. The system primarily operates through **SMS alerts**, which provide timely warnings and recommendations based on data from the Meteorological Institute and health authorities. Civil Protection coordinates these efforts, ensuring that information reaches the community quickly when heatwave conditions are expected.

Key stakeholders, including the Red Cross, local police, and the Social Department, work together to enhance outreach, especially to at-risk groups like the elderly and homeless. Health and social

[9] MCR2030. "Flames of Change: Innovating Heat and Wildfire Governance for Inclusive Communities," 28 March 2024. http://www.undrr.org/publication/flames-change-innovating-heat-and-wildfire-governance-inclusive-communities[56]

[10] https://www.cm-amadora.pt/pt/protecao-civil

departments conduct twice-weekly summer visits to about 3,000-4,000 residents, ensuring they receive the necessary support and information.

Amadora also prepares **designated shelters for emergency situations** during extreme heat events. These shelters offer safe, cooled spaces for at-risk populations, including elderly residents, individuals with health concerns, and those without adequate cooling at home. The shelters are a key component of the city's heatwave response, providing relief and immediate protection during high-temperature periods.

When a heatwave warning is issued, Amadora activates a **response protocol**. **Coordination meetings with partners** are held to finalize strategies, assign responsibilities, and craft clear messaging. To maximize clarity, short templates with color-coded alerts and recommended actions are distributed via SMS, Facebook, and other social media channels.

While largely effective, the EWS still faces challenges such as the need for multilingual messaging to better serve non-Portuguese-speaking residents. Amadora acknowledges this gap and aims to provide critical updates in English and French to ensure inclusive access to information.

In addition to these direct interventions, the city has made efforts to increase public awareness about the dangers of extreme heat. **Educational campaigns and community engagement** have helped residents understand how to protect themselves during heatwaves.

Challenges and Barriers

Amadora faces several key challenges in managing heat risks, particularly in the areas of staffing, technical expertise, data management, and financing. **Limited staffing and technical expertise** create obstacles, as there are not enough specialised personnel to operate essential software and tools needed for effective heat management (e.g., data analysis, management and visualisation tools).

Access to data also remains a hurdle, with essential information from private sectors, like banking and insurance, as well as health data from hospitals, difficult to obtain. Recognising the importance of this data for planning, Amadora is working to improve collaboration with public hospitals to access data on heat-related illnesses, emergency admissions, and hospitalization patterns during heatwaves. This information helps the city identify at-risk groups, monitor the effectiveness of interventions, and direct resources where they are most needed. By working closely with health institutions, Amadora aims to develop targeted, preventative strategies to reduce heat-related health risks across the community.

Financing is another challenge. Currently, Amadora's heat risk management initiatives rely heavily on local government budgets, supplemented by European and national funding when available. However, access to these funds can be limited compared to needs, making it challenging to secure sufficient resources. To diversify its funding sources, Amadora has explored options like public-private partnerships and is considering establishing a dedicated office to research and source green bonds, additional partnerships, European funds, and blended finance opportunities. This proposed office, with a team of around four members, will focus on financing needs for heat risk and broader climate and urban development projects. This structure is critical, as it provides the focused time and expertise necessary to deeply explore financing options, navigate complex funding mechanisms, and understand the evolving landscape of sustainable investment.

Success Factors and Outcomes

Several factors have contributed to Amadora's successful management of heat risks:

- **Strong Political Leadership:** The Mayor's active support has been essential, providing high-level alignment across departments and ensuring that heat risk management remains a city priority. This political backing has been crucial for gaining buy-in from all stakeholders;
- **Dedicated Focal Point in Civil Protection:** Civil Protection acts as the central coordinator, overseeing heat risk strategies and consolidating efforts from multiple departments. This focused leadership ensures the institutionalisation of heat risk management, efficient implementation, and streamlined decision-making;
- **Collaborative Governance:** Effective coordination between city departments has enabled a comprehensive and cohesive approach to managing heat risks;
- **Stakeholder Engagement:** Partnerships with key local stakeholders, including the Red Cross, local police, USendIt, and the Social Department, have strengthened Amadora's EWS and outreach to at-risk groups;
- **Participation in the *Making Cities Resilient Campaign***: Amadora's involvement in the *Making Cities Resilient Campaign* and *MCR2030* provided essential frameworks for assessing heat risk, completing a scorecard assessment, and developing a DRR plan that highlighted urban heat as a key vulnerability, guiding the city's resilience strategies.

For more information, please contact:

Luis Carvalho
Commander of Civil Protection Municipal Service
Amadora, Portugal
Luis.Carvalho@cm-amadora.pt

Case Study: Incheon Metropolitan City

Executive Summary

With each of the city's key heatwave indicators increasing, Incheon Metropolitan City, Republic of Korea, faces worsening risks from extreme urban heat. To mitigate these risks, the city has implemented a comprehensive approach combining EWS, public infrastructure improvements, and nature-based solutions. Key initiatives include a five-level heatwave EWS integrated with real-time monitoring, the establishment of over 1,300 heat shelters, and the implementation of data-driven interventions targeting high-risk neighbourhoods. Nature-based solutions, such as urban forests and green corridors, have been combined with built infrastructure improvements like cool roofs and smart bus shelters to create a more heat-resilient city. Strong governance and high-level political leadership have ensured effective coordination across city, district, and community levels while national policies have provided the legal and financial foundation for prioritizing heatwave management. Incheon's approach demonstrates the importance of integrating urban design, governance, and community-driven strategies to mitigate heat risks and safeguard vulnerable populations in the face of a warming climate.

Introduction and Context

The Republic of Korea has experienced a significant increase in the duration of heatwaves over recent decades, with the annual average rising from 8.2 days in the 1980s to 15.5 days in the 2010s. Two of the most severe heatwaves occurred in 1994 and 2018. The 1994 heatwave caused over 3,000 fatalities nationwide, while the 2018 event set a national record high temperature of 41°C and severely impacted Incheon, resulting in 258 heat-related patients—a 4.8-fold increase from the previous year. These crises highlighted the need for effective heat risk management and prompted national initiatives, including recognizing heatwaves as natural disasters under the Framework Act on the Management of Disasters and Safety.

In line with national trends, Incheon, the third largest metropolitan city in the Republic of Korea and home to over 3 million people, has also experienced a steady increase in heatwave indicators such as record-high temperatures, the frequency of heatwave warnings, and the number of tropical nights with temperatures above 33°C. Densely populated areas, particularly those with elderly and low-income residents, are especially vulnerable to the effects of worsening extreme urban heat in the city.

In response, Incheon has worked to strengthen its heat risk management strategies. Between 2018 and 2022, the city recorded 516 heat-related patients and 8 fatalities, reflecting the ongoing risks associated with rising temperatures. To mitigate these impacts, Incheon enacted the Heat Wave Damage Prevention Ordinance in 2019, laying the groundwork for proactive and comprehensive heatwave management. This ordinance supports initiatives such as heat shelters, data-driven early warning systems, and public education campaigns.

Governance and Institutional Arrangements

Incheon's heatwave management efforts fall under its disaster management structure and involve the participation of multiple city departments working together coordinated by the **Natural Disaster Division**, which **serves as the lead agency**[11]. This division operates within a governance

[11] UNDRR (2022a). Incheon Keeps Cool in Heat of the Moment. Making Cities Resilient 2030, 10 November 2022. https://mcr2030.undrr.org/news/incheon-keeps-cool-heat-moment

structure that is designed to integrate efforts across city, district, and local levels while ensuring collaboration with national and private stakeholders.

At the city level, the **Incheon Emergency Rescue Control Group**, led by the Chief of the Fire Defence Headquarters, provides overall coordination for emergency response measures. This group operates alongside the broader **Incheon Disaster and Safety Countermeasures Headquarters**, which is overseen by the Mayor of Incheon City. This political leadership ensures that high-level decisions are effectively communicated and executed across various departments and agencies.

The operational branch of Incheon's heatwave management lies under the **Emergency Rescue Control Organization**, which oversees the coordination of emergency rescue measures. This body is responsible for command control, establishing and executing emergency action plans, and defining the roles of various rescue agencies. Simultaneously, at the district level, the **County/District Disaster and Safety Countermeasures Headquarters** ensure localised responses. These district-level bodies manage in-house situation monitoring, resource allocation, and coordination meetings to address heatwave risks within their jurisdictions.

On the ground, response efforts are carried out by three key operational units:

1. **Field Command Post**: This unit, led by the head of the fire department, handles immediate on-site management, including issuing assistance requests and leading the first field command;
2. **Emergency Medical Center**: Focused on healthcare needs, this unit assesses hospital bed capacity, provides first aid, and triages heat-related injuries. It is led by the Public Health Director;
3. **Disaster Site Integrated Support Division**: This division, led by the Deputy Chief of the County/District, ensures the integration of resources at disaster sites, collaborates with relief agencies, and adjusts emergency policies to meet site-specific needs.

To further enhance heatwave resilience, Incheon works closely with an extensive network of **related organizations**, including government agencies, utilities, meteorological bodies, healthcare institutions, volunteer groups, and private entities. These stakeholders bring specialized expertise and resources, supporting efforts such as infrastructure upgrades, health services, and public outreach campaigns.

National efforts to reduce the effects of heatwaves began in 2005, with central ministries and local governments collaborating with the **Ministry of the Interior and Safety** to develop annual countermeasures. By 2008, heatwaves were included in the **special weather reports** issued by the **Korea Meteorological Administration (KMA)** while the **Korea Center for Disease Control and Prevention (KCDC)** began real-time monitoring of **heat-related illnesses (HRI)** in **2010**. This system expanded in **2019** with the participation of over 500 medical institutions. In **2012**, heatwaves were recognized as agricultural disasters under the **Act on the Prevention of and Countermeasures against Agricultural and Fishery Disasters** providing a basis for financial support or assistance to compensate for the agricultural damages caused by heat waves. In **2017**, the Rules on Occupational Safety and Health Standards required employers to provide shaded areas for outdoor workers[12].

A significant factor enabling Incheon's heatwave management is the 2018 revision of Korea's national Disaster Safety Act, which, for the first time, classified heatwaves as a disaster. This

[12] Kim, D.-W., Kwon, C., Kim, J., Lee, J.-S. (2020). Characteristics of Heat Waves From a Disaster Perspective. Journal of Preventive Medicine and Public Health. Korean Society for Preventive Medicine. https://doi.org/10.3961/jpmph.19.315

amendment followed the historic heatwave in 2018, which saw record-high temperatures across the country and significantly raised awareness about the severe health and environmental impacts of extreme heat[13]. This regulatory shift provided the city with a legal basis to prioritise and finance its heatwave management strategies.

In response, Incheon Metropolitan City enacted its **Heat Wave Damage Prevention Ordinance** in 2019, establishing a framework to support heatwave damage prevention projects and allocate necessary budgetary resources. This ordinance built on earlier efforts to increase heatwave-related funding in the wake of the 2018 crisis. The city's spending on heatwave measures rose dramatically, from 120 million KRW in 2017 to 550 million KRW in 2018, and further to 12.2 billion KRW in 2019. This funding supported projects such as installing heatwave reduction facilities, expanding cooling centers, and implementing public awareness campaigns.

By 2024, Incheon's total DRR budget reached 557.2 billion KRW, which represents 4% of the city's overall budget. Of this, **1.65 billion KRW (0.3% of the DRR budget) was specifically allocated for heatwave management projects**. Additionally, related initiatives, such as customized care services for the elderly and IoT-enabled[14] relief phone support for vulnerable groups, received 24.1 billion KRW in 2024. While classified as part of the welfare budget, these programs play a critical role in protecting at-risk populations from the impacts of extreme heat.

Support from the National Government

The national government provides both technical and financial support to heat risk management in Incheon. Each year, the **Ministry of Interior and Safety** issues **annual guidelines** for managing heat risks, offering cities and provinces a structured framework to develop and implement their heatwave response strategies. Financial support is also a key component with the Ministry allocating **special grant taxes** to assist local governments. In 2024, this funding covered 28% of the project costs for heatwave reduction facilities and prevention activities in Incheon Metropolitan City. This national support ensures that cities like Incheon can enhance their infrastructure and implement effective measures to protect residents from the impacts of extreme heat.

Stakeholder Involvement

- **International Organizations:** Incheon is the first MCR2030 Resilience Hub in the Asia-Pacific[15], recognized for its leadership in urban resilience. This status allows the city opportunities to both learn from other cities and share its successful strategies for managing heat risks. Through partnerships with organizations like UNDRR, Incheon has gained access and insights into global best practices and used them to improve its own heat policies. At the same time, the city shares itsexperiences, helping other cities develop stronger heatwave management strategies.
- **Civil Society Organizations:** Cross-sectoral partnerships with civil society groups, including community-based organizations like the **Autonomous Disaster Prevention Group**, play an important role in supporting vulnerable populations. These groups assist with public campaigns to promote heatwave prevention, ensure the effective operation of cooling centers, and provide direct protection for at-risk individuals, such as rural workers exposed to extreme heat.

[13] Kim, D.-W., Kwon, C., Kim, J., Lee, J.-S. (2020). Characteristics of Heat Waves From a Disaster Perspective. Journal of Preventive Medicine and Public Health. Korean Society for Preventive Medicine. https://doi.org/10.3961/jpmph.19.315
[14] A network of connected devices and technology that facilitates communication between devices.
[15] https://www.undrr.org/news/incheon-city-first-resilience-hub-asia-pacific

- **Private Sector Partnerships**: Incheon expands its network of cooling centers through agreements with financial institutions, such as banks, which provide facilities to serve as cooling shelters.
- **Volunteer Networks:** A key component of Incheon's heatwave management strategy is its network of nearly 7,000 Heatwave Helpers. These volunteers act as an extension of the city's welfare and health services, providing frontline support to vulnerable residents. They serve as the first point of contact, offering advice, administering first aid, and escalating cases requiring further intervention. This system ensures that vulnerable citizens receive assistance not only from formal governmental services but also through community-driven efforts.

Anticipatory Actions for Long-Term Heat Risk Reduction

Incheon Metropolitan City has implemented a range of urban design, planning measures, and nature-based solutions to mitigate long-term heat risks. These efforts focus on improving infrastructure, upgrading building standards, and enhancing green spaces to create a more heat-resilient urban environment.

Key Urban Planning Interventions: Incheon has implemented a range of targeted urban planning interventions to enhance heat resilience, with a particular focus on vulnerable groups such as children, low-income households, and the elderly.

A key initiative has been the installation of **cool roofs and walls**, with 19 completed by 2023. These structures are designed to reflect solar radiation and reduce heat absorption, significantly improving thermal comfort in residential buildings. Between 2021 and 2024, the city also undertook projects to improve **shading and insulation**, including installing shade screens at children's play facilities (9 locations), upgrading wall insulation (12 locations in 2022), and fitting double-glazed windows (21 locations in 2022). These measures enhance indoor comfort while reducing energy consumption in heat-affected households.

In 2023, Incheon established a **climate-friendly cooling centre**, equipped with heat-resistant materials and energy-efficient cooling systems. This facility offers a refuge during extreme heat events, especially for residents without access to adequate cooling at home.

The city has also prioritized integrating **heat-resilient designs** into public infrastructure. Across Incheon, 2,505 heatwave mitigation facilities have been deployed, including 2,061 shade screens, 90 shaded tree shelters, 48 cool roofs, 100 cooling fog systems and 206 smart bus stations. These facilities are strategically placed in high-traffic pedestrian areas to provide immediate relief from heat during the hottest months.

Incheon employs a **data-driven approach** to maximize the effectiveness of these interventions. By analysing big data related to floating populations, building density, and the distribution of vulnerable groups, the city identifies high-priority areas for deploying cooling facilities. This data-driven strategy, which incorporates satellite imagery and infrastructure information, ensures that resources are allocated efficiently and that cooling solutions reach the areas where they are most needed. Through these innovative and targeted urban planning efforts, Incheon is building a more heat-resilient city for its residents.

Adaptations to Building Codes and Land-Use Plans: Although local governments, including Incheon, cannot directly amend building laws, they can propose revisions to the central government. Incheon has focused on enhancing construction standards to include heat-shielding technologies such as window insulation films and improved wall insulation. These measures align with **Article 42 of the Framework Act on Carbon Neutrality and Green Growth** and its associated enforcement decrees, which guide local projects for addressing regional climate crises.

As part of these efforts, Incheon has implemented the **1st Green Building Construction Plan (2019-2024)**, which applies green building design standards to apartment houses and commercial facilities in private urban development projects. The city is collaborating with research institutes to develop the **2nd Green Building Construction Plan (2025-2029)**, expected to launch in 2024.

Implementation of Nature-Based Solutions: Incheon has embraced nature-based solutions as a key strategy to mitigate urban heat risks and enhance resilience against the impacts of climate change. In 2024, the city initiated a project to create 10.5 hectares of climate response urban forests across 8 locations. These forests aim to reduce urban heat islands, absorb carbon, and filter fine dust, contributing to both climate adaptation and DRR. The project involves planting trees, building trails, and establishing rest facilities at a total cost of 10.5 billion KRW, with national and municipal funding.

In addition to urban forests, Incheon is expanding its network of **green corridors and parks**, integrating green spaces into densely populated urban areas. These efforts enhance shaded pathways and improve airflow, helping to cool overheated neighbourhoods. As part of its broader urban greening strategy, the city has also installed **canopy shading at pedestrian crossings** and completed **90 shaded tree shelters**, providing critical relief in public spaces during extreme heat events.

Looking ahead, Incheon has set an ambitious target to plant **30 million trees in coming years**, creating additional green spaces to mitigate the urban heat island effect. These nature-based solutions are integral to the city's long-term resilience strategy, offering sustainable and effective ways to address rising temperatures while improving the quality of life for its residents.

Enhancement of Infrastructure and Public Services: Infrastructure improvements directly target the needs of vulnerable populations:

- **Indoor Environment Enhancements:** Specific upgrades for low-income households and elderly individuals living alone include wall insulation, heat-shielding window films, and climate-friendly materials in residential buildings. These projects are crucial for enhancing thermal comfort and reducing energy consumption;
- **Public Utilities:** Facilities such as shaded play areas and cooling centers offer accessible public services to help residents cope with rising temperatures.

Heat Risk Response

Incheon Metropolitan City has developed a heatwave response system that integrates early warnings, targeted communications, and tailored interventions to protect residents, especially vulnerable groups.

The city’s disaster safety system, integrated with the National Disaster Management System (NDMS), managed by the **Ministry of Interior and Safety,** monitors heatwave conditions in real time. This system provides detailed updates, including map-based locations and CCTV site statuses, to identify areas most affected by extreme heat. Heatwaves are categorized into five tiers: Attention Required, Alert, Warning, Dangerous, and Extreme. The system is activated when temperatures are forecasted to exceed 33°C for two consecutive days.

Communication of warnings is a key aspect of Incheon’s strategy. **Alerts are disseminated through multiple channels**, including village bulletin boards, television, radio, social media platforms, and loudspeakers broadcasting messages both indoors and outdoors. To ensure vulnerable populations—such as the elderly, homeless, and those with disabilities—are reached, **Incheon uses individual check-ins** via phones or in person through caregivers, as well as a targeted SMS system for those unfamiliar with heatwave protocols or non-Korean speakers. The Safety Dimmingdol app

and the National Disaster Safety Portal provide real-time updates on heatwave conditions, safety guidelines, and the locations of heat shelters. These efforts ensure comprehensive coverage and accessibility for all residents.

Incheon prioritizes the protection of vulnerable groups through the targeted establishment of heat shelters as a key component of its response. As of 2023, the city has established a network of 1,340 heatwave shelters, including 999 indoor shelters located in senior citizen centers, community centers, financial institutions, and social welfare facilities and 341 outdoor shelters situated in parks, under shaded trees, and beneath bridges. To enhance access, shelter locations are shared through safety apps and digital platforms, enabling residents to easily locate nearby relief spaces.

The city's heatwave response is also supported by a **functional continuity plan**, implemented in 2021 to ensure uninterrupted operations during emergencies. The plan identifies 61 core functions and includes alternative workspaces, resources, and personnel assignments. **Annual training sessions for staff** which focus on scenario-based exercises help to ensure the system remains adaptive to evolving risks.

Incheon uses big data analysis to enhance heatwave preparedness and effectively target interventions. In 2021, the city's **Data Innovation Office** and **Natural Disaster Division** conducted a comprehensive analysis using weather satellite images, population data (such as the aging index and elderly individuals living alone), building conditions, and the distribution of heat shelters. This study identified 52 high-priority areas for heatwave management, focusing on neighbourhoods with aging infrastructure and vulnerable populations.

The insights from this analysis have been used since 2022 to allocate budgets and install cooling facilities across counties and districts, ensuring that resources are directed where they are most needed. Targeted interventions include replacing insect screens in homes, providing cooling items, and prioritizing relief efforts for elderly individuals living alone. Additionally, Incheon deploys 28 mobile sprinkler trucks to cool roads and reduce surface temperatures, operating when drought conditions permit. The success of this initiative has made big data analysis a standard practice across local governments nationwide.

Challenges and Barriers

Despite clear successes, Incheon faces some challenges in implementing its heat mitigation projects, particularly in **balancing development priorities** and **securing sustainable funding**. One of the primary hurdles is competing land uses as efforts to create urban forests often meet resistance due to competing interests, such as the desire to develop commercial facilities that generate economic profit. This tension can complicate site selection and delay the implementation of critical green infrastructure projects designed to combat urban heat.

Additionally, **financial constraints** pose a persistent challenge. While national grants provide partial funding for initiatives like cooling centers and urban forests, scaling these interventions to meet the growing demands of a warming climate requires substantial long-term investments. Securing consistent funding sources remains a key barrier to fully realising Incheon's vision for a heat-resilient city.

Success Factors and Outcomes

Several factors have contributed to Incheon's success in managing urban heat risks:

- **Recognition of Heatwaves as a Natural Disaster:** The 2018 classification of heatwaves as a natural disaster under the Republic of Korea's Disaster Safety Act provided Incheon with a legal and financial foundation to prioritize heatwave management;

- **Dedicated Focal Point for Heat Management:** The establishment of a dedicated Natural Disaster Division as the lead agency for heatwave management ensures focused, coordinated efforts;
- **High-Level Political Support:** Strong political leadership, including oversight by the Mayor of Incheon City, has provided the necessary authority and prioritization for heat risk management;
- **Institutionalized Disaster Management Structure:** Incheon's institutionalized disaster management structure has been instrumental in implementing heat management strategies effectively;
- **Prioritization of Vulnerable Populations:** Incheon's heatwave management strategies place vulnerable groups at the center of its efforts. This focus ensures that resources, interventions, and policies are designed to protect those most affected by extreme heat;
- **Data-Driven Decision-Making:** The city's use of big data analysis and real time monitoring is a major strength when it comes to targeting heat risk interventions. This informed approach has ensured resources are directed to where they are most needed;
- **Collaboration with the Community:** Incheon's collaboration with community-based organizations and its network of Heatwave Helpers have been a crucial factor in its ability to support at-risk populations. This community-driven approach complements formal governmental efforts and ensures that at-risk residents are not overlooked;
- **Comprehensive Infrastructure and Nature-Based Solutions:** The city's investments in heat-resilient infrastructure and green spaces have significantly reduced urban heat risks. These efforts address both immediate heat risks and long-term urban sustainability challenges.

For more information, please contact:

AN Sung-Ah
Deputy Director
Incheon Metropolitan City
asa69@korea.kr

LEE Suk-Jin
Officer in charge of Heatwave Policy
Incheon Metropolitan City
sj503@korea.kr

Case Study: Quito

Executive Summary

Quito, Ecuador's capital, faces growing challenges from urban heat due to its equatorial location, rising temperatures, and the urban heat island effect with city centre temperatures up to 3°C higher than surrounding areas. Projections indicate further warming by 2070, intensifying risks to public health, infrastructure, and at-risk populations. To mitigate these risks, Quito has implemented a range of nature-based solutions and sustainable urban planning measures. Collaboration with international organizations and local communities has been central to Quito's strategy, emphasizing green infrastructure and public engagement. Key lessons from Quito's efforts underscore the importance of long-term planning, inclusive stakeholder involvement, and aligning heat risk strategies with wider climate adaptation goals.

Introduction and Context

Quito, located in the Andean foothills, spans various microclimates and faces increasing urban heat risks. Its equatorial position exposes the city to year-round intense ultraviolet (UV) radiation, with 44% of days in 2019 exceeding a UV index of 11, the most harmful level. Rising temperatures—already having increased by 1.1°C between 1960 and 2010—are expected to rise another 2.3°C by 2070. These changes intensify challenges such as water scarcity, energy strain, and health risks, particularly for at-risk populations[16].

The urban heat island effect exacerbates these risks, with the densely built city centre experiencing temperatures up to 3°C higher than surrounding areas[17]. However, current efforts are focused on managing a severe drought, which threatens water and energy supplies in the city's hydro-reliant economy. Water reserves could run out by early next year if the situation persists, prompting the city to declare a public emergency and pursue local solutions due to limited national support. Urban heat remains a lower priority at the national level, leaving Quito dependent on local initiatives and international partnerships to address these risks.

Governance and Institutional Arrangements

Quito is the only municipality in Ecuador with the classification of Metropolitan District, granting it increased autonomy and flexibility when it comes to governance, planning, and the design and implementation of policies tailored to local needs.

The city addresses urban heat risk management through the structured, long-term **Climate Action Plan of Quito (PACQ)**. The PACQ is built around three core objectives: (1) reducing the city's carbon footprint, (2) enhancing climate resilience and social stability through nature-based solutions, and (3) improving the overall well-being and health of residents. This phased approach sets specific targets for the short term (2023), medium term (2030), and long term (2050), providing a structured roadmap for sustainable urban development, climate action, and heat risk management[18]. Heat risk management therefore is part of the city's holistic strategy to reduce its carbon footprint, enhance resilience, and improve public well-being.

The PACQ is an important part of Quito's local policy efforts and aligns with both national and international climate change commitments. Locally, it works alongside Quito's Vision 2040 plan

[16] WHO (2022). Health and Climate Change Urban Profiles: Quito. https://www.who.int/publications/m/item/health-and-climate-change-urban-profiles-quito
[17] ibid.
[18] Interlace Hub. Climate Action Plan of Quito. https://interlace-hub.com/climate-action-plan-quito

and the city's Metropolitan Development and Land Use Plan (PMDOT), which is overseen by the **Secretariat of Habitat and Territorial Planning.**

At the national level, the PACQ aligns with Ecuador's National Climate Change Strategy 2012-2025, which focuses on adaptation, mitigation, and improving living conditions. This alignment ensures that Quito's climate initiatives contribute to both local needs and national priorities[19]. Funding for implementing activities under the PACQ comes from a variety of sources, including the national government's public budget, Quito's municipal budget, corporate investments, and international cooperation organizations. These diverse funding streams support the city's climate action initiatives and resilience-building efforts.

Another key policy framework supporting the objectives of the PACQ, including heat risk management, is the **Green-Blue Infrastructure Ordinance[20]**, which formalizes the integration of green and blue infrastructure into urban planning. The ordinance was inspired by a ruling from Ecuador's Constitutional Court, which requires the city to protect its natural environment and ensure residents can live in a healthy and balanced ecosystem. The ordinance encourages collaboration between city departments, including the **Secretariat of Habitat and Territorial Planning,** and the Metropolitan Secretariat of Environment to implement NBS in urban planning. It sets guidelines to protect existing natural areas and integrate green and blue infrastructure into urban development. The ordinance also focuses on improving governance, raising public awareness, securing funding, and ensuring these initiatives are part of broader urban plans, such as land use and territorial planning. Incentive programs such as participatory urban agriculture programmes[21] encourage individuals and organizations to implement NBS on their properties or in their urban developments.

At the heart of Quito's heat risk governance are two key municipal entities acting as the focal points for heat risk management and response: the **Metropolitan Secretariat of Environment** and the **Secretary General of Citizen Security and Risk Management**. The **Metropolitan Secretariat of Environment** is the lead agency, responsible for implementing Quito's Climate Change Strategy and overseeing critical environmental programs, including urban greening, sustainable waste management, and water resource conservation, all of which contribute to mitigating the urban heat island effect.

The Secretariat collaborates closely with the **Secretary General of Citizen Security and Risk Management**, which focuses on disaster preparedness and emergency response to climate risks. Within this department, the **Metropolitan Directorate of Risk Management** oversees specific operations, coordinating efforts to enhance resilience and protect the city's population from various hazards. Complementing these efforts, the **Secretariat of Habitat and Territorial Planning** plays a key role in overseeing territorial planning and sustainable urban development. Together, these entities form an integrated governance structure that aligns sustainable urban development with effective risk management.

Public-private collaboration advance Quito's vision of becoming a green city and is also a defining feature of Quito's governance structure. Collaborations between municipal authorities and the private sector help to facilitate eco-friendly urban development and infrastructure by investing in energy-efficient infrastructure, green building technologies, and renewable energy solutions. The **Metropolitan Public Drinking Water and Sanitation Company**, the **Metropolitan Public Cleaning Company**, and the **Metropolitan Public Company for Solid Waste Management** work with the Metropolitan Secretariat of Environment to ensure sustainable urban services, such as efficient water use and waste reduction. The Green-Blue Infrastructure Ordinance further formalizes this

[19] Interlace Hub. Climate Action Plan of Quito. https://interlace-hub.com/climate-action-plan-quito
[20] https://interlace-hub.com/municipality-quitos-blue-green-infrastructure-ordinance
[21] OPPLA. Quito: Urban Agriculture as Nature Based Solution for facing Climate Change and Food Sovereignty.

integration, aligning the work of these municipal entities with broader ecological and resilience goals. The city also collaborates with **national entities** like the **National Institute of Meteorology and Hydrology (INAMHI)**, which provides essential climate and weather data for assessing risks, though it is important to note that national data is recognised as being incomplete due to poor maintenance.

Stakeholder Involvement

Stakeholder collaboration in Quito involves the following:

- **International Partnerships:** Quito collaborates with organizations like the United Nations Environment Programme, the World Bank, and C40 Cities to access technical expertise, funding, and capacity-building resources. Participation in the *Making Cities Resilient 2030 Campaign* and later *MCR2030* further highlights Quito's commitment to resilience. As an *MCR2030* Resilience Hub, Quito shares best practices with regional partners and fosters collaboration to enhance climate adaptation and disaster preparedness. Additionally, Quito is part of the EU-sponsored CLEVER Cities initiative[22], which promotes nature-based solutions to address urban heat, flooding, and social inequalities, with a focus on co-creation and inclusive solutions;
- **Academia:** Partnerships with local academic institutions provide some research and data-driven insights;
- **Private Sector Engagement:** Local businesses and private companies contribute resources and innovations to support Quito's initiatives, including the implementation of green infrastructure, eco-friendly technologies, and sustainable building practices;
- **Local Communities and Civil Society Organizations:** Engagement with local communities and civil society organizations is integral to Quito's urban greening initiatives discussed below.

Anticipatory Actions for Long-Term Heat Risk Reduction

Quito has undertaken a series of innovative and anticipatory measures to address the risks of urban heat. These efforts are embedded within its broader strategies for urban design, planning, and nature-based solutions, aiming to enhance resilience while fostering a sustainable urban environment.

Nature-based solutions are at the heart of Quito's heat mitigation strategy, including community tree planting, the creation of urban gardens and green corridors, and the regeneration of creeks and green roofs. Often, these solutions are being implemented in close collaboration with local communities such as in the San Enrique de Velasco neighbourhood. By 2030, the municipality aims to provide over 20 square meters of green space per inhabitant, significantly reducing the urban heat island effect and enhancing the quality of life for residents[23].

Quito has focused heavily on **integrating green infrastructure into its urban fabric**. The city's "Urban Green Network" (Red Verde Urbana or RVU) developed by the Secretary of Territory of the Metropolitan District of Quito has allowed for the creation of a system of green corridors that connect conservation areas, urban parks, and recreational spaces.

[22] Clever Cities. Quito, Ecuador.
[23] WHO (2022). Health and Climate Change Urban Profiles: Quito. https://www.who.int/publications/m/item/health-and-climate-change-urban-profiles-quito

Efforts to **incorporate cool roofs and vertical gardens** across urban developments are gradually gaining momentum. These features mitigate heat absorption, reduce energy consumption, and improve air quality. Quito's commitment to preserving ventilation corridors further facilitates natural airflow in densely populated areas, a vital strategy for maintaining passive urban cooling.

Quito's **updated building codes prioritize ecological design**. New constructions are encouraged to include features such as solar panels, rainwater harvesting systems, and water recycling facilities. These eco-friendly designs not only support broader sustainability goals but also mitigate urban heat through reduced reliance on traditional energy sources and better water management.

Quito's **land use plan has also been updated to address heat risks.** Policies now emphasize protecting ecological zones, restricting urban sprawl into sensitive areas, and incorporating climate resilience into the city's Metropolitan Development and Territorial Planning Plan. These measures ensure that urban expansion aligns with environmental preservation, reducing the strain on natural cooling mechanisms.

Challenges and Barriers

Despite its proactive and innovative measures, Quito faces several significant challenges in implementing and sustaining its urban heat risk management strategies.

Quito's efforts to address urban heat risks have been primarily driven by local initiatives, with **limited direct support from the national government.** The national government has not prioritized urban heat as an urgent concern, leading Quito to rely on its municipal budget, international partnerships, and, where possible, national funding for specific projects. Even in the context of the current drought and energy crisis, Quito recognises that it will need to complement national support with innovative local solutions if they are to meet pressing challenges. Quito's difficulties in this regard highlight the importance of enhanced collaboration with and resources from the national level to effectively tackle both immediate emergencies and long-term climate resilience efforts.

Another challenge relates to **inconsistencies in data collection and maintenance at the national level**, which impede Quito's ability to effectively monitor urban heat and assess vulnerabilities. Comprehensive data is fundamental for understanding the impacts of urban heat and developing detailed scenarios to guide decision-making in climate adaptation strategies. Without this foundation, efforts to address urban heat risks lack the precision needed for long-term success. This further emphasizes the need for improved national-local coordination and enhanced data systems.

Coordinating efforts across multiple municipal departments, external partners, and the national government has proven complex at times. A lack of coordination and consistent support from the national level amplifies these challenges. Quito seeks to compensate for these gaps by seeking innovative local solutions and leveraging international partnerships to address the city's needs. This approach demonstrates the city's resilience and adaptability but also demonstrates the pressing need for stronger national engagement and resources.

Community Ownership: While programs such as participatory urban gardening have shown significant potential to enhance urban cooling and foster biodiversity, their long-term impact has sometimes been undermined by challenges in sustaining engagement and ensuring consistent maintenance. The municipality acknowledges that fostering a sense of ownership among residents requires improved support mechanisms and recognizes its responsibility to provide the resources, education, and ongoing guidance necessary for success. At the same time, empowering residents to actively participate and contribute is essential. Strengthening mutual responsibility and

cooperation through communication, joint decision-making, and targeted incentives will be key to ensuring the sustainability and resilience of these initiatives.

Financial Constraints: Quito's financial landscape poses another significant barrier. The municipal budget is stretched thin by competing priorities leaving limited resources for heat risk management efforts. To bridge the gap, Quito leverages international grants and partnerships; however, these funds are typically tied to specific projects and cannot fill the need for a stable and flexible municipal funding base.

Competing Priorities: Urban heat risk management competes for attention and resources with more immediate and current crises, such as ongoing droughts and water scarcity. These pressing challenges have disrupted water availability and strained the national energy infrastructure, which relies heavily on hydroelectric power. As a result, focus is being diverted away from other issues like urban heat risk mitigation.

Competing Land Uses: As Quito continues to deal with rapid urbanization, the pressure to develop new infrastructure and housing poses challenges to preserving ecological corridors and green spaces. Limited land availability in densely populated areas further complicates efforts to expand green infrastructure. This tension requires negotiation between development needs and environmental priorities, as well as policies that enforce ecological preservation while accommodating growth.

Addressing these challenges will require Quito to strengthen community engagement strategies, secure more consistent and diversified funding, and adopt integrated urban planning approaches that balance immediate needs with long-term resilience. By doing so, the city can build on its innovative measures and ensure the sustainability of its climate initiatives.

Success Factors and Outcomes

Quito's approach to urban heat risk management has been marked by several success factors, even if challenges remain. These factors highlight the city's strengths in governance, innovation, and collaboration:

- **Autonomous Governance and Long-Term Planning:** Quito's status as Ecuador's only Metropolitan District grants it a high degree of autonomy which allows the city to tailor its policies and strategies to local needs. The development of the PACQ exemplifies this autonomy and provides a structured, phased, and long-term roadmap for sustainable urban development and climate change adaptation planning with heat risk management integrated into broader goals;
- **Strong Institutional Framework:** The collaboration between the Metropolitan Secretariat of Environment and the Secretary General of Security, Citizenship, and Risk Management demonstrates a well-coordinated governance model. Together the departments oversee programs addressing heat adaptation, urban greening, disaster preparedness, and climate resilience, creating an integrated approach to risk management;
- **International Collaboration:** Quito has leveraged its participation in global initiatives to address local urban challenges. These partnerships have provided technical expertise, funding, and innovative solutions for urban greening and climate resilience;
- **Community Involvement** has been a key factor in the success of initiatives like urban gardening, tree planting, creek restoration, and green corridor development. These projects highlight the potential of collaboration between residents and the municipality to address climate and heat risks. Despite some challenges in sustaining engagement, these efforts have already demonstrated benefits, including increased urban greenery throughout the

city. This reinforces the importance of actively involving local stakeholders in planning and implementation as a cornerstone for climate resilience.

For more information, please contact:

Santiago Sandoval
Secretario de Ambiente
Quito, Ecuador
santiago.sandoval@quito.gob.ec

Patricia Carrillo
Directora Metropolitana de Gestión de Riesgos
Quito, Ecuador
jessica.carrillo@quito.gob.ec

Case Study: Cape Town

Executive Summary

Cape Town faces growing challenges from rising temperatures and heat waves. Its unique geography—between two oceans with dense urban areas and mountains—creates microclimates that intensify heat exposure. The urban heat island effect, combined with socioeconomic disparities, disproportionately affects at-risk groups, particularly in low-income neighbourhoods and informal settlements with limited greenery and cooling resources. The city's response includes a Heat Wave Action Plan, heat risk mapping, integrating heat considerations into urban planning, and nature-based solutions like urban greening. Key lessons emphasize data-driven targeting of heat-vulnerable areas, partnerships for expertise and funding, and inclusive planning that prioritizes vulnerable communities. Cape Town's approach underscores the importance of proactive governance, collaboration, and public engagement to build resilience against urban heat.

Introduction and Context:

Cape Town, home to over 4.7 million people and South Africa's fastest-growing city, faces increasing heat risks due to rapid urbanization and rising temperatures. Its geography—between two oceans with dense urban areas and mountains—creates microclimates that intensify heat exposure. The urban heat island effect is particularly exacerbated in areas with limited vegetation, such as the Central Business District, industrial zones, and low-income neighbourhoods.

Urban design, including extensive concrete infrastructure and sparse tree cover, combined with socioeconomic disparities, drives heat exposure. Vulnerable groups, such as residents of informal settlements, outdoor workers, and those with limited mobility, often lack access to cooling resources like air conditioning or green spaces. These disparities are most acutely felt in areas with inadequate resources to mitigate heat risks. Recent heat events highlight the urgency of action.

In February 2024, temperatures reached 41.6°C, straining public health and municipal services, increasing heat-related illnesses, and deepening inequalities. Cape Town has responded by prioritizing heat risk management as part of its climate resilience strategy, integrating immediate and long-term measures to protect residents and infrastructure[24].

Governance and Institutional Arrangements

Urban heat risk management is relatively new for Cape Town, and the governance structure to address it is still evolving. Recent efforts have focused on developing foundational systems to support long-term implementation rather than immediate, on-the-ground action. The **Heatwave and High-Heat Day Action Plan**, officially approved in November 2023, represents a key step toward managing the growing risks of extreme heat. While the plan operates as a standalone initiative focused on immediate risk reduction during heatwaves, it is directly tied to the city's **Climate Change Action Plan and Resilience Strategy,** where it serves as a deliverable under the goal to "Reduce Immediate Risks to Health During Heatwaves." This broader goal also includes related actions, such as developing cooling centres and implementing an early-warning and real-time heat

[24] https://www.capetown.gov.za/Media-and-news/Local government needs to lead in tackling challenges of extreme heat and C40 CFF (2022). Banking on a Just and Green Recovery. https://c40cff.org/knowledge-library/banking-on-a-just-and-green-recovery-lessons-from-9-cities

[1] C40 Cities. Cape Town, South Africa. https://www.c40.org/cities/cape-town/

C40 Cities. Nairobi, Kenya.

monitoring system. By aligning these distinct but interconnected efforts, the city ensures a cohesive approach to managing both immediate and long-term heat risks.

To date, the city has concentrated on building the technical and infrastructural systems necessary for implementation, emphasizing readiness and strategic coordination. This process also involved capturing and formalizing existing approaches into a cohesive strategy, ensuring a clear roadmap for future action[25].

Cape Town's approach to managing heat risks is organized into four key areas, each targeting a specific part of the challenge:

- **Risk Readiness**: This involves preparing the city for heat waves before they happen. Key measures will include setting up cooling centres, improving early warning systems, and ensuring the health sector is ready to handle an increase in heat-related health issues;
- **Risk Response**: Actions taken during a heat wave to protect people and reduce harm. This includes emergency responses, public safety measures, and real-time efforts to address heat impacts as they happen;
- **Research and Knowledge Management**: Building technical tools and systems to better understand and manage heat risks. Efforts will include defining temperature thresholds for emergency actions, improving early warning systems, and collecting data to identify patterns and improve future responses;
- **Risk Prevention**: This structure will focus on long-term strategies to reduce heat risks overall. Examples include planting trees and enhancing biodiversity to cool urban areas and reduce the heat island effect. While not necessarily part of the Heat Action Plan itself, many of these efforts are included in existing and related policies like the Urban Forest Policy and the Biodiversity Strategy.

Cape Town's Heat Action Plan is supported by three important governance structures, each with a specific role in managing heat risks. The **Risk and Resilience Department** acts as the main coordinating body, monitoring progress and aligning efforts across departments and governance bodies. As the primary custodian of the **Heat Action Plan**, the department oversees its implementation, tracks progress, and secures resources. It functions as a convening point rather than an implementing agency, ensuring alignment across multiple departments and external partners:

- **Corporate Business Continuity Coordinating Committee** focuses on long-term planning to ensure the city is ready for heat risks and that essential services remain uninterrupted. Its main role is to maintain the resilience of municipal operations and prepare for potential disruptions caused by extreme heat;
- **Disaster Risk Management Center (DRMC)** plays a central role in Cape Town's efforts to manage heat events. It oversees the **Festive Season Readiness Task Team**, soon to be renamed the **Summer Readiness Task Team**, which addresses the unique challenges of the hot season. These include ensuring adequate lifeguard coverage at beaches, managing public safety, and maintaining crowd control during the peak summer tourism period. The DRMC leads the city's outreach and response efforts for heat-related risks. Leveraging its extensive experience in managing floods and fires, the center organizes heat awareness campaigns, educational events, and community outreach in high-risk areas. It also

[25] See also https://www.capetown.gov.za/Media-and-news/Local government needs to lead in tackling challenges of extreme heat

coordinates immediate response measures during heat waves and ensures the readiness of health services to handle surges in heat-related illnesses;

- **Climate Change Response Forum**: This newly established forum focuses on coordinating research and data collection for all climate-related risks, including heat. It plays a central role in managing knowledge and ensuring that decisions are informed by the best available information.

These structures work together to ensure that Cape Town can effectively prepare for, respond to, and learn from heat-related challenges.

Support from the National Government

National policy provides overarching guidance for climate adaptation but offers limited direct support for local heat risk management. Sectoral adaptation plans are still in early stages of development and have yet to prioritize heat risks. With no dedicated national funding for heat-related challenges, Cape Town relies on general grants, property taxes, and tariffs to finance its initiatives while designing and implementing specific strategies independently.

Stakeholder Involvement

External partnerships also play a role in Cape Town's management of heat risk:

- Collaborations with organizations such as **C40 Cities**, the **Resilient Cities Network**, and the **Red Cross Climate Center** have helped the city to build technical knowledge and capacity around heat adaptation;
- **World Bank:** Another significant initiative is the **World Bank Heat Mapping Project**, supported by the National Treasury Cities Support Programme, the Swiss Secretariat for Economic Affairs, and the Global Facility for Disaster Risk Reduction. This project produced city-scale heat maps to inform urban planning and emergency management, building Cape Town's institutional resilience to future heat events. The project's implementation was led by a local NGO (Community Organisation Resource Centre) and supplemented with technical expertise from private sector partners (CAPA Strategies), who provided sensor equipment and conducted data analysis. A notable aspect of the project was its community involvement. **Thirty volunteers from at-risk communities participated** in mapping heat and sharing their observations and experiences. This grassroots engagement sensitized the community to heat risks and empowered residents to take proactive measures in their own environments;
- **World Resources Institute:** Cape Town has partnered with the World Resources Institute's Data for Cool Cities initiative to better understand and address urban heat risks. This collaboration focuses on collecting and analysing detailed data on factors such as green spaces, tree cover, buildings, and paved surfaces that shape urban thermal comfort. Through this partnership, Cape Town was able to gain a nuanced understanding of heat risks, enabling data-informed interventions to improve urban resilience.

Anticipatory Actions for Long-Term Heat Risk Reduction

Urban Design and Planning Strategies: The City of Cape Town is actively integrating heat risk considerations into its urban planning and design processes. This includes **reviewing its urban design policy** to incorporate heat risk management, providing guidance for private developers, and shaping the design of public spaces. **Heat risk maps have been added to high-level planning tools**, helping identify urban heat island areas and enabling targeted interventions, such as tree planting

and cooling infrastructure. Additionally, a **mapped network of green spaces** has been integrated into these tools to ensure that green infrastructure plays a key role in urban development and zoning decisions.

Nature-Based Solutions: Cape Town is also expanding its **urban greening efforts**, focusing on reducing the heat island effect through a targeted tree-planting program. This initiative identifies high-risk areas using urban forest canopy and heat island maps. This urban greening program is led by the **Parks and Recreation Department**, with support from **Environmental Managemen**t, the **Human Settlements Directorate**, the **Transport Directorate**, and **Sustainable Energy Markets (Climate Change Team)**, in collaboration with NGOs and civil society organizations[26].

Cape Town has identified **several challenges related to increasing the coverage of initiatives** related to nature-based solutions. In private development, cost is a significant barrier. Low- to middle-income housing projects can rarely allocate resources for features like green walls or advanced cooling designs. High-end commercial developments, however, increasingly incorporate smart building features and passive cooling designs.

Climate and soil conditions pose another barrier. Cape Town's Mediterranean climate, characterized by hot, dry summers and cold, wet winters, is not ideal for many vegetation types. In winter, tree roots can be submerged in water, which many species cannot tolerate. Sandy soil in many parts of the city require significant preparation and maintenance to support tree planting.

Finally, the need for **long-term maintenance of green infrastructure** was also identified as a key barrier. Infrastructure such as such as green walls deteriorates due to insufficient maintenance, especially in Cape Town's challenging climate. Initial installations may look promising, but without ongoing care, they can fail, limiting their effectiveness.

Cape Town has identified a range of actions to overcome some of these obstacles as outlined in its Climate Change Action Plan. These include ensuring sustainable irrigation and maintenance to support tree survival, campaigning to engage private landowners and state entities in tree planting, maintenance, and the protection of existing trees. Success will be monitored by tracking tree survival rates and evaluating their effectiveness in mitigating heat.

Additionally, Cape Town is leveraging partnerships with organizations like C40 Cities, the World Resources Institute, and the World Bank to enhance data collection and improve planning precision. Detailed heat risk maps developed through these collaborations allow for targeted interventions in vulnerable streets and neighbourhoods. Scaling these efforts across the city remains a priority to expand the impact of nature-based solutions.

Heat Risk Response

Cape Town's approach to heat risk response is evolving and currently focuses on **public education and outreach** rather than automated or threshold-based emergency responses. The DRMC is the primary agency responsible for implementing these measures, though heat risk management is a relatively new area of focus. Internally, various city departments have also started integrating heat risks into their planning and service delivery and it is recognised that the City Health Department will play a key role in the operationalisation of the Heat Action Plan.

The DRMC conducts targeted outreach in areas identified as the hottest parts of the city. These efforts are informed by data analysis from weather stations operated by the South African Weather Service. Educational events and materials are distributed at community locations, including beaches during the summer. These materials cover topics such as: understanding heat risks and

[26] See also https://www.capetown.gov.za/Media-and-news/Local government needs to lead in tackling challenges of extreme heat

heat waves, practical tips such as staying hydrated, wearing appropriate clothing, and recognizing symptoms of heat stroke, and preventative advice tailored to Cape Town's climate[27].

Outreach often takes place alongside other public safety programs. For example, while city departments run drowning prevention campaigns or distribute wristbands to help reunite lost children with their parents, the DRMC provides information about heat risks at neighbouring stands. Plans are underway to launch a broader heat awareness campaign through social media, radio, and other low-cost media platforms.

Cape Town recognizes the need for **effective public communication to address heat risks** and plans to draw on lessons learned during the 2017 drought crisis. During that time, the city discovered that combining two key elements—clear communication about what the government was doing and practical advice for the public—were highly effective in building trust and encouraging collective action. Known as "message coupling," this approach shifted the narrative from one-sided warnings and instructions to more collaborative resilience. While Cape Town has not yet applied this strategy specifically to heat risk, the city recognizes the importance of doing so. Current outreach efforts, such as distributing materials in heat-prone areas and running smaller-scale awareness campaigns on social media and radio, are modest but lay the groundwork for more comprehensive communication in the future. These campaigns focus on practical tips, such as staying hydrated, wearing appropriate clothing, and recognizing the symptoms of heat stroke, rather than presenting heat risks as abstract or distant climate change issues.

The city plans to build on these initial efforts by integrating message coupling into its heat communication strategy. This would combine practical advice for individuals with visible municipal actions to reassure the public and foster a sense of shared responsibility. However, Cape Town acknowledges that scaling up these efforts will require additional resources, partnerships, and grant funding.

The City of Cape Town is also planning to develop and implement **a network of cooling centers** as part of the Cape Town Resilience Strategy and Climate Action Plan. These centers, created in collaboration with government and private stakeholders, will provide safe, accessible spaces for residents and visitors during extreme heat events. The initiative includes public communication to ensure awareness of these facilities and aims to incorporate multipurpose designs in City buildings to enable their use as cooling centers. This effort involves coordination across several city departments, including Sustainable Energy Markets (Climate Change Team), supported by Disaster Risk Management, City Health, Facilities Management, Parks and Recreation, Environmental Management, Library and Information Services, Urban Planning and Design, and Development Management. External stakeholders include national and provincial government bodies, as well as businesses and industrial associations.

In disadvantaged neighbourhoods of Cape Town, most residents do not have access to air conditioning, home swimming pools, or beaches to help deal with heatwaves. In response to these issues, the city has already installed six spray park cooling centers in lower-income neighborhoods. These parks use only 15-20% of the water used by medium-sized municipal pools while still providing residents, especially children, with a way to escape the heat[28].

The City of Cape Town is also planning to **develop and implement an early-warning and real-time heat monitoring system** to enhance its response to extreme heat events. Key actions include establishing a network of real-time heat-monitoring stations in areas not currently covered by South African Weather Service (SAWS) stations and sharing relevant data with SAWS. Additionally,

[27] Ibid.
[28] Singh, R., Arrighi, J., Jjemba, E., Strachan, K., Spires, M., and Kadihasanoglu, A. (2019). Heat Wave Guide for Cities. Red Cross Red Crescent Climate Centre. https://www.ifrc.org/document/heat-wave-guide-cities

the city will create a public communication platform, such as a web-based tool or mobile app, to provide real-time heat information. This initiative is led by the Sustainable Energy Markets (Climate Change Team), with support from Disaster Management, City Health, and Scientific Services as well as collaboration with external research institutions and international and national non-governmental partners.

Financing

From 2015 to 2017, Cape Town suffered from severe droughts due to extreme urban heat, culminating in an unprecedented water shortage crisis in 2018, driven by the previous years' rainfall deficits. Given the city's threatened water supply and unstable built resilience, Moody's downgraded their credit worthiness in 2017. Despite the downgrading, Cape Town turned to an innovative form of debt financing to support their adaptation goals, and the same year issued a green bond valued at 1 billion Rand. Not only was the bond listed on the Johannesburg Stock Exchange, but it was also the first in South Africa to meet the Climate Bond Initiative's stringent requirements, which ensure alignment with the goals of the Paris Agreement. Moreover, the bond was rated GB1 (excellent) by Moody's. The listing and these high ratings were key to building investor trust and assurance of the genuine climate-aligned nature of this debt vehicle. The bond itself was four times oversubscribed at its issuance, and its proceeds are being used toward water security management, coastal protection, and other heat and non-heat related adaptation projects across the city[29].

Challenges and Barriers

- **Technical and Financial Resource Constraints:** Cape Town, like many cities, faces resource limitations, including insufficient staffing and a lack of technical expertise in areas like climate modelling and urban heat island mitigation. Budget restrictions also hinder the expansion of heat management initiatives. Despite these challenges, Cape Town's success with alternative climate financing, like the 2017 Green Bond they used to raise 1 billion Rand for climate adaptation, demonstrates the city's potential capacity to mobilize further resources[30]. These funds, originally used to combat water scarcity, prioritized inclusivity and transparency, providing a blueprint for similar models to address heat risks;
- **Data Gaps and Geographic Complexity:** Effective heat risk management faces challenges posed by the lack of granular, real-time data. The South African Weather Service provides reliable forecasts but cannot capture localized variations caused by Cape Town's unique geography, microclimates, and urban heat islands, which can be up to 5°C hotter than surrounding areas. This gap complicates efforts to identify and address the needs of the most heat-vulnerable zones. Additionally, Cape Town's coastal and inland regions often experience vastly different temperatures on the same day, making uniform forecasting ineffective. Emerging plans to develop the aforementioned early warning and real-time heat

[29] C40 CFF (2022). Banking on a Just and Green Recovery.

[30] Global Heat Health Information Network and WMO-UNDRR Centre of Excellence for Climate and Disaster Resilience. (2024a). An Assessment of Heat Action Plans: Global standards, good practices and partnerships (December 2024, Pre-Publication Draft).

[2] Global Heat Health Information Network and WMO-UNDRR Centre of Excellence for Climate and Disaster Resilience. (2024b). Narrative Analysis: Case studies in heat resilience. (December 2024, Pre-Publication Draft).

Global Infrastructure Hub. Cape Town Green Bond. https://www.gihub.org/innovative-funding-and-financing/case-studies/cape-town-green-bond/

monitoring system, which would establish localized monitoring stations and a public communication platform, though still in early stages, will address some of these gaps;

- **Public Awareness:** Heat is not widely perceived as a significant risk by the public in Cape Town's relatively moderate climate. The association of summer with holidays and outdoor activities reduces public vigilance, increasing exposure to heat risks. In response, public awareness campaigns are being implemented with a focus on cost-effective methods like free media to raise awareness;
- **Lack of Emergency Thresholds**: The city has not yet developed specific temperature thresholds that would trigger automatic heat wave emergency responses. Scientific studies are ongoing to determine what these thresholds should be, tailored to Cape Town's unique climate and vulnerability patterns. Establishing this will be one of the key activities that informs the city's early warning system;
- **Limited Resources**: The public awareness and education campaigns are relatively new and operate with modest budgets, limiting their reach and scale. Initial efforts prioritize cost-effective methods like free media. Increased funding is needed to move beyond or complement awareness and education activities;
- **Limited Technological Infrastructure:** The absence of advanced systems to collect localized heat data, such as sensors in heat-prone zones, limits the city's ability to target interventions effectively. In response, Cape Town is piloting sensor-based temperature monitoring in municipal buildings and other urban areas. The city is also evaluating the feasibility of new technologies to ensure cost-effective and scalable solutions before broader implementation.

Success Factors and Outcomes

Despite the challenges, Cape Town's progress in managing climate risks, including urban heat, reflects its ability to learn from past crises. The severe 2017 drought, which nearly led to "Day Zero," when water supplies were nearly exhausted shifted the perception of climate risks from distant concerns to urgent realities, driving heightened preparedness and influencing strategies for other challenges like urban heat laying the groundwork for action.

Partnerships have been instrumental in strengthening Cape Town's ability to address rising urban heat risks. By collaborating with global organizations and leveraging external expertise, the city has enhanced its technical capacity, improved its data systems, explored diverse financing options, and implemented community-focused interventions.

For more information, please contact:

Amy Davidson
Head of Climate Change
City of Cape Town, South Africa
amy.davison@capetown.gov.za

Case Study: Nairobi

Executive Summary

Nairobi, Kenya's capital and home to 5 million people[31], is one of Africa's fastest-growing cities and faces escalating risks from urban heat. Alongside global temperature rises, these risks are magnified by rapid urbanization and unchecked development. Over recent decades, the city's forest cover has plummeted while rising temperatures compound the challenges faced by its residents. These losses, combined with the expansion of impervious surfaces, have intensified the urban heat island effect and reduced the city's ability to manage rising temperatures.

These challenges are especially acute in informal settlements, where limited access to cooling infrastructure heightens health and socioeconomic vulnerabilities. At-risk populations are disproportionately affected by extreme heat, compounding existing inequities. The replacement of green spaces with concrete and asphalt has further worsened Nairobi's resilience to rising temperatures, making the city increasingly susceptible to the impacts of urban heat.

To address these issues, Nairobi has initiated urban heat management strategies such as expanding green infrastructure, including green roofs and tree planting, and integrating heat-sensitive urban design into city planning. Despite these efforts, fragmented governance remains a significant barrier, with siloed efforts and a lack of cross-sectoral coordination hindering the alignment of initiatives. Additionally, the absence of a clear urban heat strategy and accompanying implementation plan limits Nairobi's ability to prioritize and scale effective interventions. These challenges are further compounded by resource constraints and critical gaps in technical capacities, data collection and analysis. A coordinated, long-term approach is needed to overcome these barriers and build Nairobi's resilience against escalating heat risks.

Introduction and Context

Nairobi's increasing exposure to urban heat risks has raised important questions about the city's resilience to rising temperatures. These risks stem from a combination of global climate change, regional weather patterns like El Niño, and local factors such as rapid urbanization and the urban heat island effect. With its population exceeding 5 million, the city has witnessed a dramatic reduction in forest cover, shrinking from 14% in the 1970s to just 3% in recent years while bushland areas nearly halved, leaving the city with diminishing green spaces to mitigate rising temperatures[32]. Concurrently, the expansion of impervious surfaces has compounded the city's heat challenges, particularly for residents in informal settlements who face limited access to cooling infrastructure and green spaces.

The urban heat island effect is particularly pronounced in Nairobi, where rapid development has prioritized construction over preserving natural landscapes. This has worsened vulnerabilities among low-income populations, who are disproportionately affected by rising temperatures and their associated health risks. These challenges demonstrate the urgent need for Nairobi to prioritize urban heat management as part of its broader climate resilience and sustainable urban development strategies.

[31] C40 Cities. Nairobi, Kenya. https://www.c40.org/cities/nairobi/
[32] Njeru, G. (2024) "The Roof Does All the Work": The Rise of Green Roof in Nairobi. African Arguments, 19 June 2024. https://africanarguments.org/2024/06/the-roof-does-all-the-work-the-rise-of-green-roofs-in-nairobi/

Governance and Institutional Arrangements

Heat stress has been recognized as a national priority in Kenya's **National Climate Change Action Plan**, but its integration into local urban governance structures responsible for environmental and climate change issues remains limited.

Within Nairobi City County, **the Green Nairobi Sector** provides the overarching governance framework for addressing environmental sustainability and climate resilience. The Green Nairobi Sector is designed to enhance Nairobi's resilience to climate-related challenges and promote sustainable urban development. It encompasses three sub-sectors, each addressing aspects of environmental and urban management:

- **Environment Sub-Sector:** Leads efforts on issues such as solid waste disposal, air and noise pollution control, climate change mitigation, and management of parks and recreation. It is within this sub-sector that **the Climate Change Department** resides, tasked with managing urban heat;
- **Food, Agriculture, and Natural Resources Sub-Sector**: Focuses on coordinating Nairobi's food systems, promoting agricultural safety, managing crop and livestock development, controlling pests and diseases, providing veterinary services, ensuring animal welfare, and advancing urban forestry initiatives;
- **Water and Sewerage Sub-Sector:** Oversees water and sanitation services, including water conservation, catchment protection, flood mitigation, land reclamation, water pollution control, and enforcement of quality standards. It also manages rural water supply planning, borehole development, and maintenance.

Although the Environment Sub-Sector, particularly its Climate Change Department, has identified urban heat as a strategic priority alongside climate change and clean air, targeted interventions remain limited. Urban heat receives less attention compared to more established efforts such as solid waste management, air quality improvement, and urban forestry.

Urban heat is still a relatively new and underdeveloped focus. Efforts by the Climate Change Department relating to urban heat were described as primarily arising as co-benefits of broader environmental programs rather than as intentional, targeted interventions specifically addressing urban heat. Key examples cited include:

- **Solid Waste Management**: Activities such as minimising landfill emissions, promoting recycling, and enforcing bans on open burning are primarily driven by objectives like solid waste disposal and air pollution control. While these efforts reduce overall emissions and localized heat sources—particularly by eliminating heat-generating practices like open burning—they are not specifically designed to tackle urban heat. Their influence on urban heat levels is indirect and highly localised, with a relatively smaller impact;
- **Energy and Transport Initiatives:** Encouraging renewable energy adoption and the transition to electric vehicles contributes to reducing waste heat but is driven by broader emissions reduction goals.

While the Green Nairobi Sector provides the broader governance framework, interventions targeting urban heat to date have been led by **the Built Environment and Urban Planning Sector**. This sector's focus on modifying the physical urban landscape and incorporating green infrastructure has positioned it as one of the primary actors addressing urban heat directly. Nationally, the **Ministry of Lands, Public Works, Housing, and Urban Development** provides policy direction that informs urban planning efforts, with the Built Environment and Urban Planning Sector adapting

these guidelines to Nairobi's local context and employing methods to enforce them[33]**.** However, the efforts Built Environment and Urban Planning Sector operate in isolation of those in the Climate Change Department, and the siloed nature of governance has hindered their alignment with a cohesive approach to urban heat mitigation. The **lack of a comprehensive urban heat strategy** and implementation plan further limits the integration of these efforts, leaving urban heat as an emerging issue rather than a fully coordinated priority across sectors.

Stakeholder Involvement

Partnerships between international organisations and the municipal government have provided technical assistance and capacity-building for environmental and heat risk activities. For example, the **Safer Nairobi Initiative** supports urban heat mitigation as part of a broader approach to city safety, focusing on land use and planning strategies that consider environmental and social well-being.

Additionally, Nairobi's membership in the **C40 Cities Climate Leadership Group** enhances its potential for impactful collaboration. As Vice Chair of the C40 Steering Committee, Nairobi's Governor represents 13 African cities, positioning the city as a key player in shaping strategic climate initiatives across the continent. While this role provides Nairobi with significant opportunities to access technical expertise, funding, and global best practices, there is room for the city to better leverage these resources to strengthen its urban heat mitigation efforts and broader climate resilience strategies.

Anticipatory Actions for Long-Term Heat Risk Reduction

Nairobi has advanced in heat risk reduction primarily through the city's efforts on modifying the physical urban landscape and incorporating green infrastructure led by **the Built Environment and Urban Planning Sector**. **Green roofs are a central element of Nairobi's heat mitigation strategy.** The Architectural Association of Kenya (AAK) reports that nearly 200 buildings in Kenya—including apartments, offices, and hotels—already feature green roofs, with approximately 30 more under construction, predominantly in Nairobi. In East Africa, green roof infrastructure construction is growing at a rate of 12% annually, signalling a regional shift toward sustainable urban development. However, the **high costs and technical complexity of installing green roofs, particularly on existing buildings, present a significant challenge.** These roofs often require structural reinforcements and regular maintenance, which limits their accessibility to wealthier property owners in private housing[34].

To address these barriers, the Ministry has taken proactive steps to improve governance and encourage adoption. It has directed the Built Environment and Urban Planning Sector and professional bodies to **establish stricter green building codes**, recently making green roofs mandatory in specific parts of the city. Additionally, the Ministry aims to attract more companies specializing in green construction, providing tax incentives to drive competition and reduce costs. By integrating regulatory oversight with economic incentives, the Ministry seeks to make green roofs more affordable and widespread[35].

The Built Environment and Urban Planning Sector is also steering broader efforts to integrate nature-based solutions into Nairobi's urban design. Initiatives such as **tree planting, rooftop**

[33] Nairobi city Council. Build Environment and Urban Planning Sector. https://nairobi.go.ke/built-environment-and-urban-planning-sector/
[34] Njeru, G. (2024) "The Roof Does All the Work": The Rise of Green Roof in Nairobi. African Arguments, 19 June 2024. https://africanarguments.org/2024/06/the-roof-does-all-the-work-the-rise-of-green-roofs-in-nairobi/
[35] Ibid.

gardens, and green walls are being promoted to enhance the city's green cover and provide natural cooling. **Public parks and open water bodies** are also being incorporated into urban spaces to create cooling effects and improve drainage. Meanwhile, **zoning regulations** are under review to encourage retrofitting existing infrastructure with heat-mitigating features like shaded walkways and cool roofs.

Heat Risk Response

Nairobi currently lacks a dedicated early warning system for heatwaves, reflecting the fact that urban heat management is a relatively new area of focus for the city. **This year marks the first time urban heat has been prioritized, and existing mechanisms remain limited in scope and functionality**.

The city relies on weather forecasts provided by the Kenya Meteorological Department to monitor temperature trends. While this department has access to relevant data, the information is primarily used for general weather updates rather than for specific heatwave warnings. Critical weather conditions are communicated to the public through mainstream media channels, which can reach a wide audience. Additionally, a significant portion of Nairobi's population owns smartphones, enabling access to weather alerts shared via digital platforms. However, these updates are often limited to extreme weather events, leaving gaps in awareness and preparedness for heat-related risks.

Weekly official updates on weather conditions are distributed within the city government but rarely reach the public in a timely or impactful manner. This lack of targeted communication and specialized warning systems hinders the city's ability to adequately prepare for and respond to heatwaves.

As urban heat management gains traction in Nairobi, developing an effective early warning system for heatwaves will be critical. Such a system would need to include efficient data collection, timely dissemination of information to the public, and collaboration across city departments and stakeholders to ensure preparedness and resilience.

Challenges and Barriers

Managing heat risks in Nairobi presents significant challenges, exacerbated by the city's rapid urbanization and the fact that urban heat is a relatively new area of focus. The city's surging pace of development is outstripping its ability to integrate climate-sensitive planning, leading to increasing urban heat and a loss of green spaces. These challenges are further complicated by resource constraints, technical and knowledge gaps, fragmented efforts, low public awareness, and a lack of reliable data systems.

- A major obstacle for the Climate Change Department in addressing urban heat effectively is the **absence of a dedicated strategy for heat management, along with the lack of an accompanying implementation plan, compounded by limited resources.** The department operates with only eight staff members responsible for all activities. Without a clear strategy and implementation plan to guide efforts, even the existing limited workforce struggles to undertake targeted actions. Financial constraints further restrict the department's ability to develop and execute comprehensive or additional heat mitigation programs.
- **Technical and Knowledge Gaps:** Urban heat management demands specialized expertise that the Climate Change Department currently lacks. Many staff members lack training in managing the complex and cross-sectoral nature of urban heat. Existing knowledge

management systems and stakeholder engagement efforts are described as insufficient, limiting the city's ability to build capacity and foster collaboration.

- **Fragmentation and Lack of Coordination:** Urban heat is a cross-sectoral issue, but efforts to address it remain fragmented and siloed. Currently, the **Green Nairobi Sector** and the **Built Environment and Urban Planning Sector** work independently on related initiatives. While these efforts are valuable, they lack a centralized framework for coordination, which can lead to conflicts over mandates and misaligned priorities.
- **Data Gaps and Analytical Limitations:** Another key challenge is the lack of reliable data systems for urban heat. Nairobi relies on general weather forecasts from the Kenya Meteorological Department, but there is no localized data mapping heat-prone areas and temperature trends. Without such data, it is difficult to plan targeted strategies or evaluate the effectiveness of interventions. The absence of analytical tools or expertise was identified as posing a challenge to the development of evidence-based policies and undermines the city's ability to secure funding.
- **Policy and Institutional Barriers:** Although urban heat has recently been recognized as a priority, it remains underrepresented in Nairobi's policies and frameworks. The lack of dedicated policies or structured guidance for implementation reflects its status as a new area of focus, leaving urban heat management fragmented and lagging behind other areas of focus. Without formal institutionalization, it struggles to compete with more established areas like clean air, delaying systematic and scalable interventions.
- **Low Awareness and Engagement:** Public understanding of urban heat and its impacts was described as being low, which will limit community support and participation in current and future mitigation strategies. While some school programs are beginning to address the issue by incorporating climate and heat educational activities, these initiatives are not yet widespread or fully integrated into the curriculum. Historically, urban heat has not been prioritized in Nairobi's climate agenda, leading to delayed adoption of necessary interventions and insufficient allocation of resources. Expanding educational efforts and fostering broader community engagement will be essential to build a stronger foundation for urban heat mitigation.

For more information, please contact:

Grace Ojiayo
Assistant Director Climate Change
Nairobi City Council Government, Kenya
Grace.ojiayo@gmail.com

Common Success Factors

The analysis of cities highlights key factors that have enabled effective urban heat risk management. Successful local governments have taken proactive, structured approaches, integrating heat-specific strategies into broader climate change, urban planning, and disaster resilience efforts. These actions include creating dedicated heat management plans, stakeholder collaboration, and allocating resources effectively. The following section outlines the key steps cities have implemented to address urban heat challenges and protect vulnerable communities:

- **Dedicated Heat Action Plans:** Cities with dedicated Heat Action Plan have adopted a proactive and structured approach to addressing urban heat challenges. These plans provide a clear roadmap for implementing targeted interventions, aligning stakeholders, and allocating resources effectively. By focusing on heat-specific strategies, cities have been able to integrate resilience measures into broader urban planning and disaster management frameworks, ensuring a comprehensive and coordinated response to heat risks.
- **Allocated and Earmarked Specific Budgets for Heat Risk Management:** Cities have dedicated financial resources specifically for addressing heat risks, ensuring sustained funding for initiatives. This approach supports the implementation of heat resilience measures such as early warning systems, urban greening projects, infrastructure upgrades, and community outreach programs. By earmarking budgets, cities demonstrate a long-term commitment to mitigating urban heat and protecting at-risk populations**.**
- **Secured Innovative and Diverse Financing Mechanisms**: Cities have actively pursued a range of funding options to support heat risk management initiatives, including grants, international climate funds, public-private partnerships, and green bonds. These proactive approaches have enabled the scaling and sustainability of urban heat mitigation efforts.
- **Dedicated Focal Points:** Successful cities have created dedicated roles or teams tasked with leading urban heat initiatives. These focal points ensure sustained focus, efficient coordination across departments, and accountability for achieving results.
- **Secured Strong Political Support:** Leadership and commitment from mayors and political leaders have been pivotal in driving urban heat risk management. Their convening power has united multiple and diverse stakeholders, enabling cross-sectoral collaboration. Political support has also provided the necessary momentum for cities to prioritize urban heat risks, secure increased resources, and enact supportive policies, ensuring long-term commitment and impact.
- **Institutionalized Heat Risk into Disaster Management Structures:** Cities have embedded heat risk into disaster management plans, ensuring a structured approach to preparedness, response, and recovery. This integration enables timely and effective action during heat events.
- **Prioritized At-Risk Populations:** A targeted focus on at-risk groups—such as the elderly, children, homeless people and low-income communities—has ensured an equitable approach to urban heat management. Tailored interventions have reduced health risks and improved community resilience.
- **Embraced Data-Driven Decision-Making:** Cities have leveraged advanced analytics, heat mapping, and vulnerability assessments to guide decision-making. This approach provides a detailed understanding of heat impacts, helping to prioritize resources and design interventions where they are needed most.

- **Promoted Public Awareness and Engagement:** Recognizing the importance of community involvement, cities have engaged residents through awareness campaigns, participatory planning, and co-implementation of solutions. This creates a sense of shared responsibility and enhanced resilience at the community level.
- **Implemented Nature-Based Solutions.** Initiatives like urban greening, urban forests and tree planting, green roofs and walls, and cooling corridors have been widely adopted to combat urban heat offering additional co-benefits in areas like air quality and community wellbeing and opportunities for educational and recreational activities.
- **Developed Early Warning Systems:** Cities have developed and implemented tiered early warning systems that provide timely alerts about impending heatwave events. These systems enhance preparedness by empowering communities, healthcare providers, and emergency services to take proactive measures, minimize health risks, and prevent heat-related illnesses and fatalities.
- **Facilitated Cross-Sectoral Collaboration and Coordination:** By fostering collaboration between the range of departments and authorities involved in urban heat risk management such as environment, health, disaster management, and urban planning, cities have ensured cohesive and integrated responses to urban heat risks.
- **Engaged in Multi-Stakeholder Collaboration:** Cities have actively engaged academia, non-governmental organizations, local communities, and other stakeholders, enriching their urban heat strategies with diverse expertise, perspectives, and shared resources. These partnerships have enhanced the effectiveness of heat risk management initiatives.
- **Strengthened International Collaboration:** Cities have participated in global networks to exchange knowledge and best practices. These collaborations have enabled access to international funding, expertise, and innovative approaches, while also allowing cities to share and reflect upon their own successful strategies.
- **Leveraged Private Sector Partnerships:** Collaborations with private sector partners have facilitated the development of innovative solutions for the challenges posed by urban heat in areas such as early warning systems, financing mechanisms, and urban development. These partnerships have enabled faster and more effective implementation of heat resilience projects.

Common Challenges and Barriers

An analysis of cities and their experiences in managing urban heat risks reveals several common barriers that have hindered the implementation of effective strategies. It is important to note that certain elements identified as success factors in the previous section may also appear as barriers in this analysis. This reflects the dual nature of these factors—while some cities have managed to leverage resources like robust and integrated data systems or political leadership to their advantage, others face significant challenges due to the absence of these same elements, These disparities highlight the varied capacities and contexts in which cities operate, demonstrating that what works as a strength in one setting can be a critical gap in another.

- **Financial Barriers:** Financing is frequently described as the greatest challenge for local governments seeking to adopt and scale urban heat management strategies. Many initiatives rely heavily on municipal budgets, which are often insufficient to address the growing demands of comprehensive heat risk management. While supplemental funding from national governments or international sources, can provide additional support, access to these resources is limited, highly competitive and not usually sustainable. This mismatch between funding availability and need poses a substantial barrier to implementing impactful and scalable solutions.

  Adding to this challenge is the nature of urban heat reduction strategies, which often deliver benefits over the long term compared to the immediacy of default cooling responses like air conditioning. While solutions such as cool roofs, vertical greenery, and ventilation corridors significantly reduce life-cycle costs through lower operating expenses and environmental benefits, their high fixed, startup and maintenance costs deter decision-makers. This **first-cost bias** is further exacerbated by municipal governments' limited financial resources and restricted access to innovative financing mechanisms, such as debt financing from international institutions or issuing fixed-income securities. Since urban heat is inherently a localized issue, adaptation and mitigation efforts typically fall under the responsibility of local governments. However, without the authority or capacity to secure diverse funding sources, cities often struggle to overcome financial barriers. This challenge is especially acute in developing countries, where high discount rates, upfront affordability concerns, and a lack of viable financing options perpetuate reliance on short-term, less sustainable solutions. As a result, cities are often deterred from investing in nature-based solutions or retrofitting built environments despite their long-term advantages.

- **Lack of Dedicated Heat Action Plans:** Cities that lack dedicated Heat Action Plans struggle to coordinate efforts, involve key stakeholders, and allocate resources effectively. This can lead to siloed responses and missed opportunities to include heat-specific strategies in broader urban planning and disaster management efforts.

- **Technical and Knowledge Gaps:** Gaps in expertise and technical capacity represent significant barriers for a number of local governments in adopting effective and varied urban heat management strategies. Until relatively recently, the urban heat island effect was often viewed as a cyclical condition to be mitigated with increased air conditioning rather than as a systemic issue requiring comprehensive and sustainable solutions. This reliance on air conditioning, ironically, exacerbates the problem by generating additional waste heat and greenhouse gas emissions, further intensifying urban heat challenges.

  In many cities, urban heat has only become a priority in the past decade, resulting in limited awareness among policymakers and decision-makers about its long-term impacts and the

necessity of sustainable cooling measures. This has contributed to a widespread lack of accessible information on best practices and innovative solutions to draw from, as well as insufficient data to understand how extreme heat is affecting urban communities. These knowledge gaps make it challenging for city officials to identify effective interventions, prioritise at-risk populations, or develop data-driven cooling action plans.

Some local governments also describe a lack of the technical expertise required to manage urban heat comprehensively. Specialized skills in climate modelling, data analysis, and sustainable urban design are frequently unavailable, particularly in developing countries. Without this expertise, cities struggle to map heat-prone areas, assess vulnerabilities, or monitor the effectiveness of interventions. The absence of these capabilities hinders the ability to adopt targeted and scalable heat risk strategies.

- **Limited Leveraging of Public-Private Partnerships:** Cities described a lack of economic, legal and technical capacity struggled to establish and manage public-private partnerships for urban heat management efforts. Consequently, they miss out opportunities to access to important resources, solutions and technical expertise. This gap reduces their capacity to build resilience, especially for at-risk populations, leaving them less prepared to address the growing risks of urban heat.

- **Fragmented and insufficient data systems** were identified as a major barrier to urban heat management efforts, limiting local governments' ability to identify heat-prone areas, assess vulnerabilities, and design targeted interventions. Many cities lack granular, real-time data on urban heat islands, temperature variations, and the needs of at-risk populations or it remains fragmented and poorly integrated across systems. This shortfall complicates resource allocation, prioritisation, and the overall development of solutions. The lack of robust and integrated data systems can serve to undermine cities' ability to attract funding and support because data-driven proposals are often required by financiers and national bodies. This challenge is particularly critical when addressing the needs of the most at-risk populations, whose risks and priorities may be overlooked without detailed, localized data, Cities that can effectively demonstrate the extent of the need and present well-planned, evidence-based strategies for addressing it are far more likely to secure the funding necessary to implement equitable and impactful solutions.
- **Lack of Early Warning Systems:** The absence of effective early warning systems for heatwaves is a critical barrier to urban heat risk management in many cities. These systems are essential for providing timely alerts, enabling cities to prepare and protect vulnerable populations during extreme heat events. However, many local governments described a lack of the infrastructure, technology, and protocols required to implement these systems effectively. Without real-time heat monitoring or targeted warning mechanisms, cities struggle to identify and communicate heat risks. This leaving at-risk populations—such as the elderly, outdoor workers, and residents of informal settlements—more vulnerable to the impacts of extreme heat. General weather updates, which are commonly used in place of dedicated heat warning systems, fail to provide the localized, actionable information needed to safeguard communities.
- **Poor Public Awareness and Community Engagement:** A number of cities expressed that the public lack a clear understanding of the risks associated with extreme heat, often perceiving it as a seasonal inconvenience rather than a serious threat to health, well-being, and infrastructure. This lack of awareness reduces the urgency for action and undermines public support for sustainable, long-term solutions. Adding to this challenge is the complexity of multi-stakeholder coordination, which often limits the ability to implement tailored, locally relevant engagement strategies. The need to coordinate across various

agencies, organizations, and sectors can result in community involvement being sidelined. Outreach challenges, particularly when it comes to regularly and comprehensively engaging vulnerable and marginalised populations, further exacerbate this issue. As a result, action plans may be developed without adequately addressing the most pressing needs of those acutely affected by extreme heat, leading to inequitable and ineffective outcomes.

- **Managing Complexity in Heat Mitigation Choices:** Effectively managing urban heat requires cities to navigate a broad range of possible strategies, each with its own costs, benefits, and implementation challenges. The diversity of cooling options—ranging from urban planning and nature-based solutions to passive cooling and energy efficiency—can overwhelm decision-makers, making it difficult to identify the most suitable approaches for their specific context. This abundance of choices often leads officials to default to the strategy with the lowest upfront cost, even if it offers limited long-term benefits.
- **Lack of Coordination Across Sectors** Effective urban heat risk management requires effective multi-sectoral collaboration, yet many cities face challenges in achieving this coordination. Responses to urban heat risks are often fragmented and siloed, with limited communication or shared objectives between key departments. The successful implementation of sustainable cooling practices, such as increasing urban tree cover or creating green infrastructure, highlights the complexity of cross-sectoral collaboration and coordination. These initiatives often require input and alignment from various municipal departments, alongside involvement from NGOs, academic institutions, and private stakeholders. However, the differing mandates, priorities, and practices of these actors creates conflicts and delays, significantly hindering the timely and effective completion of projects. Without clear frameworks or leadership to facilitate this collaboration, cities struggle to design and execute cohesive and comprehensive responses to urban heat risks.

Key Recommendations for local governments

Urban heat risk management requires a multifaceted and proactive approach to address the growing challenges posed by heatwaves and rising temperatures in cities. The recommendations outlined below build on the successes and barriers identified in urban heat resilience efforts. These recommendations provide actionable strategies for cities to mitigate the impacts of extreme heat whilst striving for equitable, sustainable, and community-driven solutions. By addressing data gaps, promoting innovative financing, encouraging cross-sectoral collaboration, and prioritizing at-risk populations, cities can transform challenges into opportunities to build resilience and protect their communities for the increased threat posed by urban heat. As heat risk management is relatively new to many local governments, it is critically important that national governments benefit from these recommendations and further provide support through structured national guidelines for urban heat risk management.

Conduct a City Baseline Heat Risk Assessment and Mapping

A climate or **heat assessment that fills in data gaps related to risk and vulnerability is a key first step** in effective city action planning. Given many cities' tight budgetary restraints, the initial process of identifying populations and assets most at risk and taking stock of existing green, blue, and grey infrastructure is vital for the efficient and strategic deployment of limited resources. **Partnering with academic institutions, international organisations, research organizations, and data providers** can support and enhance data collection, analysis, and heat mapping efforts in contexts lacking in resources, ensuring a comprehensive understanding of urban heat risks and vulnerabilities.

Set Clear Heat-Planning Goals and Metrics

It is important to **design achievable targets** that respond to the needs first identified in a city's baseline assessment. Goals can be city-wide or adjusted for population density at a neighbourhood level depending on their scope, but importantly, they should be **specific and clearly measurable**. For example, when implementing nature-based solutions, cities could set targets for the total area of green space per resident, for residents' proximity and access to that space, or for percentage of canopy cover.

Develop a Comprehensive Heat Action Plan and Integrate Heat Resilience in Long-Term Urban Planning

A Heat Action Plan is essential for coordinating efforts, reducing vulnerabilities, and building resilience to urban heat risks. Heat often accumulates in cities due to the prevalence of surfaces that absorb sunlight, anthropogenic sources of waste heat, and the shape of the built environment. **Cities can then reduce urban heat through a mixture of solutions including long-term anticipatory actions** such as adjustments to urban design and regulations, use of reflective surfaces and materials, adding shading structures in key public areas, increasing street tree coverage, preserving and establishing green and blue spaces, and increasing ventilation through cooling urban geometry, **as well as effective response mechanism** including heat risk early warning systems. It is important for policymakers to **develop a wide portfolio of heat mitigation and management strategies and Heat Action Plans** such that all different drivers of the UHI effect are covered. Such strategies and plans should consolidate existing heat management initiatives across sectors for strategic alignment and link to broader development, DRR, and climate policies. The Heat Action Plan must **include a detailed implementation framework** with clear steps, timelines, and accountability

mechanisms with regular **monitoring and evaluation.** Such **heat resilience strategies must be integrated into long-term planning** to ensure city-wide collaboration, coordinated efforts in implementation, and reducing competing priority challenges.

Ensure Cooling Solutions are Sustainable and Climate Friendly

In a warming world, energy-intensive cooling strategies that fail to consider their contributions to the climate crisis will only exacerbate the issue of urban heat in the long-term. In addition to prioritizing nature-based solutions, cities should also focus on implementing a variety of passive cooling techniques, ensuring that buildings are as energy and thermally efficient as possible, and retrofitting dense urban environments with district cooling systems.

Establish a Heat Alert System and Response Mechanism

Using a **tiered alert system** as a basic measure to inform the public of anticipated periods of extreme heat can greatly help mitigate the risks posed by the UHI effect. Such an alert system also reduces strains on public health facilities during heat waves. **Establish clear frameworks for consistent and effective messaging during heat emergencies, focusing on reaching at-risk populations, including those without digital access and individuals who do not speak the primary language.** The system can be supplemented **with educational information** on how to reduce vulnerability to and symptoms of heat-related illnesses during extreme hazard conditions. These measures should be a central part of city's Heat Action Plan to ensure public safety during extreme heat events.

Harness Political Leadership

High-level political support and leadership are essential to drive transformative action on urban heat management. Leaders have the **convening power to align stakeholders**, **coordinate across departments, and mobilize resources.** Engage mayors and other senior figures by highlighting the economic, social, and health impacts of urban heat, as well as the co-benefits of action. Align initiatives with leaders' priorities and build support through briefings and partnerships with key stakeholders.

Establish a Dedicated Focal Point for Heat Risk Management and Strengthen Coordination Across Essential City Systems

Urban heat risk management is a multifaceted challenge that spans areas including urban planning, public health, emergency management, and environmental sustainability. **Heat risk management solutions should complement other essential priority strategies for cities** such as improving inclusive mobility, water distribution, sewage, energy, food systems, and more — all of which place considerable pressure on local budgets and technical capacities. **Coordinated planning across these areas then is crucial not only for maximizing cost saving but also for fostering more effective system-wide resilience** given that the intended impacts of many other targeted urban development plans could be amplified by complimentary heat resilience strategies. A dedicated focal point is necessary for coordination across sectors, providing leadership and accountability across diverse departments and stakeholders. Designate a focal point to lead heat risk management efforts and oversee coordination and collaboration across departments and sectors, ensuring that Heat Action Plans are efficiently implemented, integrated with other city initiatives and contribute to unified city's heat risk reduction goals.

Build Awareness on Heat Risk Reduction at All Levels of Society

Capacity development and education programs to support enhanced understanding of heat risks are essential. Increased understanding of the UHI effect among local government officials, for example, can help them better plan and implement long-term solutions to address extreme urban heat. At the same time, active public engagement can also extend beyond the planning process through **educational and outreach programs** that aim to inform people on how to best protect themselves from hazard conditions and make effective use of city resources.

Engage All Relevant Stakeholders and Leverage Public Engagement

The success of cooling solutions requires **active and cross sectoral agency participation**. Key departments to engage with could include those for city planning, budgeting, buildings, environment, parks, land use, public works, utilities, maintenance, and roadways. These groups, as well as **relevant private and civil society stakeholders**, should be included throughout the design and implementation process of various solutions. In addition, low-income and marginalized communities tend to be more exposed to the dangers of urban heat. **Actively engaging citizens in these communities through participatory planning or budgeting processes** ensures that city initiatives are equitable and suit the actual needs of those most affected by extreme heat. Particularly, **by regularly communicating with community leaders and representatives of various at-risk population groups such as women, youth, persons with disabilities,** decision makers can identify which areas of the city lack access to public cooling initiatives and ensure that those initiatives are made more accessible. Establishing platforms or programs to encourage citizens, local businesses, and NGOs to propose and pilot innovative heat resilience solutions can encourage community engagement and the development of scalable grassroots innovations. These participatory approaches should be embedded in the Heat Action Plan to ensure inclusivity and equity.

Strengthen Partnerships to Enhance Heat Risk Management

A diverse network of partnerships is vital for pooling resources, expertise, and innovation to tackle challenges of urban heat. Foster collaborations with local, national, and international organizations to enhance urban heat resilience. Collaborate with private companies, NGOs, and research institutions to access technical expertise, innovative solutions, and potentially funding. Leverage private sector resources and technology to implement impactful interventions, and work with international organizations to bring in global knowledge, support and visibility to urban heat initiatives. Exchanges, experience sharing and learning with other cities facing similar heat risk challenges can be extremely beneficial. Strong partnerships should be explicitly outlined in the city's Heat Action Plan to ensure a coordinated, well-resourced, and innovative approach to managing heat risks.

Leverage Public–Private Partnerships.

Local governments should actively seek out , foster and maximise public-private collaborations to strengthen their urban heat management efforts. By developing clear legal frameworks, offering incentives to attract private investment, and investing in staff capacity to coordinate collaborations, cities can better engage with private sector stakeholders. These partnerships will enable access to

resources, innovative solutions, and technical expertise, enhancing cities' ability to build resilience and address the needs of at-risk groups effectively and equitably.

Seek Diverse and Sustainable Financing for Heat Management

Sustainable financing is essential for implementing, scaling, and maintaining heat risk management strategies, especially in resource-constrained contexts. Local governments can allocate dedicated budgets, introduce local taxes earmarked for adaptation and heat management, and integrate heat risk reduction into urban development funding. Incentivize cooling solutions like green roofs, reflective materials, and energy-efficient designs to engage the private sector. Develop a financial strategy with diversified funding streams such as green bonds, public-private partnerships, municipal revenue mechanisms, insurance products or blended financing to mobilize resources will provide more stable financial foundation for addressing urban heat risks. Partnering with international organizations and NGOs to access grants as seed-funding to initiate urban heat risk reduction can also be explored. These financial strategies should form a central part of the Heat Action Plan, to ensure implementation feasibility.

Build Local Technical Capacities

Investing in ongoing capacity building is essential for equipping stakeholders with the skills, knowledge, and tools they need to manage urban heat risks. Training programs for government officials, urban planners and architects, community leaders, and emergency responders ensure they remain updated on best practices, emerging technologies, and any innovative heat management solutions. Collaborate with academic institutions and international organizations to facilitate workshops, certifications, and knowledge-sharing sessions. Building capacity at all levels strengthens institutional readiness, promotes adaptive management, and builds a culture of resilience.

Key Recommendations for national governments

National governments play a key role in helping local governments manage heat risks effectively. By providing policy guidance, technical expertise, and economic support, they empower local authorities to implement actions that are tailored to their specific challenges. Additionally, national governments act as a bridge, aligning local initiatives with national climate adaptation and DRR strategies, and international frameworks, ensuring coherence and a greater potential for maximizing impact. Through these efforts, national governments can build a stronger and more coordinated approach to heat risk management that addresses both national priorities and local needs.

Conduct Heat Risk Mapping

Heat risk mapping has been shown to be crucial for understanding the scope and impact of rising temperatures. Heat risk mapping allows governments to take proactive and informed action. With this in mind, national governments should develop detailed heat risk maps to identify the most at-risk populations and geographic areas affected by rising temperatures. By integrating geospatial, climate, and socioeconomic data, heat risk maps can provide insights for targeted interventions, efficient resource allocation, and equitable policymaking to address urban heat challenges.

Develop Heat Risk Management Strategies and Plan

Rising temperatures are affecting people, infrastructure, and the environment in significant ways, and addressing these impacts requires a clear plan. National governments should seek to develop detailed heat risk management strategies and a Heat Action Plan, emphasizing heat risk as a key priority. These strategies should also be embedded into national climate policies and National Adaptation Plans (NAPs) in order to ensure alignment with broader adaptation goals. A strong Heat Action Plan should outline targeted interventions, and the resources needed to achieve them, and establish frameworks for collaboration among the different sectors and levels of government. By integrating heat risk into national planning, governments can address rising temperatures proactively, protect their most at-risk populations, and strengthen overall resilience against future climate impacts.

Provide Supportive Legal Frameworks and Guidelines for Localizing Heat Risk Management Implementation

Local governments play a key role in heat risk management, but they need clear legal and policy support to act effectively. The effective localization of heat risk management strategies depends on national governments providing the necessary support to align local actions with broader national policies and ensure coordinated responses. These measures are Important to empower local governments, ensure alignment with national policies, and to build a coordinated, impactful responses to urban heat challenges. Key elements could include mandating the appointment of heat risk focal points at the local level, requiring the establishment of coordination mechanisms across departments, and setting clear responsibilities for heat risk preparedness and response. Guidelines should also provide actionable steps, best practices, and resources tailored to the unique needs of municipalities. By creating an enabling environment, national governments can ensure that local authorities are equipped to implement impactful, region-specific heat risk management solutions.

Revisit Existing Building Codes and Land Use Planning

Building codes and land use policies are powerful tools for shaping heat-resilient cities. National governments should review and update these regulations to ensure they support modern and environmentally friendly cooling solutions and address the challenges of rising urban heat. Building codes should incorporate requirements for heat-resilient infrastructure, land use planning guidelines should promote heat-sensitive urban design, including strategies like urban greening, shading, and improved street layouts to enhance airflow and reduce heat buildup. Additionally, frameworks should encourage the integration of nature-based solutions provide natural cooling benefits. Strengthening compliance and enforcement mechanisms will be key to ensuring that existing and updated regulations are effectively implemented on the ground.

Embed Heat Risk in Multi-Hazard Early Warning Systems

Extreme heat events are becoming more frequent and severe, making timely warnings essential to save lives and reduce disruptions. National governments should establish heat indicators and develop a system to trigger warnings during periods of high heat risk. These systems should include guidelines on anticipatory actions, ensuring communities, local governments, and emergency services are prepared to respond rapidly to minimize health risks and disruptions. By embedding heat risk into broader warning frameworks, governments can ensure a comprehensive and coordinated approach to managing multiple hazards, enhancing resilience and reducing the worst effects of extreme heat.

Strengthen Financial support

A defined and coordinated national approach to financing urban heat risk management is essential, given the cross-regional nature of heat risks and their impact on multiple sectors. This could include creating dedicated funding streams or integrating heat risk management into existing budgets for sectors like urban planning, environmental management, public health, and disaster management. By channelling resources through these sectors, governments can ensure heat resilience is embedded in broader development efforts. A national approach to fundraising, such as accessing international climate funds, issuing green bonds, or fostering public-private partnerships, can provide additional resources to support more large-scale interventions. Clear and equitable financial frameworks will help local governments implement sustainable and impactful solutions to manage urban heat challenges.

Provide Continued Capacity Development Support

Recognising the importance of specific and technical skills for urban heat risk management across sectors, national governments should support the creation of training programs and curriculums tailored to the needs of key stakeholders, including government officials, urban planners, architects, community leaders, and emergency responders. These programs should focus on practical solutions, the latest technologies, and best practices for managing heat risks, ensuring stakeholders are well-prepared and up to date.

Actively Support Experience Sharing and Co-creating of Solutions

Encouraging collaboration and learning is essential for the effective management of urban heat risks. National governments should support exchanges between national and local governments, between local governments, and with other countries both regionally and internationally. These exchanges help share best practices, identify lessons learned, and support the development of tailored solutions to address specific needs.

Creating platforms for workshops, forums, and peer learning allows stakeholders to discuss challenges and successes. Involving local governments in these efforts ensures that solutions are practical and grounded in real-world experiences. Engaging in international networks also provides access to global expertise and resources, helping governments access to proven strategies more quickly. By supporting collaboration at all levels, national governments can accelerate the spread of effective approaches, strengthen local capacity, and create solutions that are better informed and more impactful.

Annex 1 Additional Resources for Local Governments

There are many publicly available resources that provide specific guidance on issues regarding heat risk. The following section aims to provide a brief, helpful snapshot of these resources, serving as a compilation of supportive literature on topics such as action planning, risk assessments, financing, and nature-based solutions. While some of these toolkits focus more broadly on climate change adaptation, the approaches they outline are equally applicable to heat risk more specifically. For example, many of the considerations involved in financing adaptation, mainstreaming climate governance, or assessing general climate risks are the same as when focusing on just heat, for heat, too, is being driven by anthropogenic climate change and rising temperatures.

Heat Risk Planning Guides and Toolkits

- **Heat Resilience Toolkit (ICLEI, 2021)**: ICLEI has prepared this toolkit to facilitate the identification of the causes of heat stress in Indian cities and provide relevant solutions for preventing them.
- **Urban Heat Toolkit (Georgetown Climate Center):** a useful toolkit for local governments that outlines of the benefits, challenges, and policy frameworks to be considered when implementing various UHI mitigation measures. Particularly, this toolkit focuses on cool roofs, green roofs, cool pavements, and urban forestry.
- **Planning Tools for Combatting Extreme Heat (The White House):** provide a collection of publicly available resources to inform heat-conscious urban planning, community education, and investments.
- **Beating the Heat: A Sustainable Cooling Handbook for Cities (Cool Coalition, 2021)**: provides a comprehensive overview of urban cooling approaches including key intervention strategies that cities can use, frameworks for heat action plans, and city case studies and best practices regarding various cooling strategies.
- **Heatwave Guide for Cities (IFRC, 2019)**: provides a comprehensive overview of how to prepare for the heat season, create a heat-health early warning system, and provide immediate relief during a heatwave. The guide also includes a section on urban planning for heat risks, which includes a discussion of urban greening, green roofs, increasing reflectivity, cool pavements, and blue infrastructure.

Examples of Heat Strategy and Action Plans

- **Turn Down the Heat Strategy and Action Plan (Western Sydney, 2018):** Through this initiative, officials and community stakeholders have developed a cool suburbs tool and urban heat planning toolkit that can freely be used to strengthen resilience and assess action plans.
- **Climate Action Plan of Quito 2020-2050:** Quito's climate action plan includes a number of strategies for managing heat risk and implementing nature-based solutions.
- **City of Cape Town Climate Change Action Plan:** Cape Town's climate action plan has several sections that focus specifically on urban cooling, water security, and drought readiness.

- **Ahmedabad Heat Action Plan:** provides an overview of Ahmedabad's heat risk management strategies, including building public awareness, implementing cool roofs, and building capacity among healthcare professionals.
- **Mapped: Cities with a Climate Action Plan (C40, 2022):** This mapping tool provides an overview of all the C40 cities that have a published climate action plan and what those plans entail. While these plans often focus on climate change more broadly, many of them include sections on heat risk management.
- **Cities100 Report (C40, 2019)**: provides a comprehensive compilation of case studies and city action plans related to climate resilience. A key focus of the report is urban heat with many of the case studies providing innovative best practices for how to tackle the UHI effect.

Case Compilations

- **Heat Island Community Actions Database compiled (US Environmental Protection Agency):** provides dozens of examples of state, municipal, and local actions that have been taken to combat the UHI effect. It is helpfully sorted into location, type of cooling activity, and description of the initiative so that other local leaders can implement similar such solutions in their own communities.
- **Neighbourhood Level Cooling: Experiences from C40's Cool Cities Network (C40, 2021):** uses specific city case examples from the C40 network to provide in depth recommendations for how to achieve urban cooling at a local level.
- **Good Climate Governance in Practice: Case Studies from Leading Cities (C40, 2021):** provides an in-depth explanation of the key principles of good climate governance as well as provides a series of city case studies demonstrating best practices in budgetary mainstreaming, stakeholder and cross-sectoral collaboration, data collection, and more. These broader climate adaptation strategies are equally applicable to the more specific adaptation issue of urban heat given that budgetary mainstreaming and the other governance principles discussed here are the same principles that must be facilitated for effect heat risk management.

Risk/Loss and Damage Assessments

- **Cities Climate Change Risk Assessment Guidance (C40, 2018):** aims to provide concise guidance to cities on how to develop a climate risk assessment report. It provides an overview of the methodology and components of the assessment as well as best practices for its implementation.
- **Climate Risk and Vulnerability Assessment: Training Guide for Cities (CDP, 2022):** provides a summary of the key learnings from CDP's 2021 capacity-building program for local authorities in Asia, using three case studies to explain how to conduct climate risk assessments and how to interpret their results.
- **Loss and Damage: Challenges and Opportunities for City Leadership (C40, 2023):** outlines a series of city actions focused on measuring and minimizing economic and non-economic loss and damage. It also discusses best practices for enhancing city-to-city cooperation and knowledge sharing around this topic.

Financing

- **Accelerating Urban Climate Finance in Low- and Middle-Income Economies (Cities Climate Finance Leadership Alliance, 2023):** identifies five key areas of work to help increase the volume and effectiveness of urban climate finance in line with current multilateral development bank reform agendas.
- **How to Increase Financing for Urban Climate Adaptation and Resilience (Cities Climate Finance Leadership Alliance, 2022):** This policy brief is directed at national policymakers and lays out how they can work with other key stakeholders (subnational governments, local leaders, public financial institutions) to scale finance for climate adaptation and resilience.
- **An Analysis of Urban Climate Adaptation Finance (Cities Climate Finance Leadership Alliance, 2021):** aims to assess the state of urban climate adaptation finance and to prototype analysis methods to address current data and methodology limitations.
- **Focused Adaptation: A Strategic Approach to Climate Adaptation in Cities (C40, 2021):** identifies and explains 15 high-potential actions across five climate hazards – extreme heat, drought, wildfire, inland flooding and coastal flooding – and strategies that can help cities build systemic resilience.
- **New Perspectives on Results-Based Blended Finance for Cities (World Bank, 2019):** provides a deep dive on blended finance and several debt and equity instruments as well as a number of accompanying case studies.
- **Making Blended Finance Work for the Sustainable Development Goals (OECD, 2018):** presents a comprehensive assessment of the state and priorities for blended finance as it is being used to support sustainable development in developing countries. It describes concepts and definitions, presents an overview of actors and instruments, and discusses lessons learned from blending approaches.
- **Building Climate Resilience in Cities Through Insurance (Cities Climate Finance Leadership Alliance, 2021):** provides an overview of insurance products and mechanisms relevant to urban climate resilience and best practices for their implementation.
- **Debt for Climate Swaps (GCF, 2024):** outlines different debt-for-climate swap transaction structures, including bilateral and multipartite approaches, and assesses their application across varied country contexts.
- **How to Decide if Green Bonds are Right for Your City (C40, 2022):** provides detailed guidance on how to issue green bonds and what the issuance process means for cities and other actors.
- **How Cities can Attract Private Finance for Climate Action (C40, 2024):** Strong policy signals, enabling policies, a bankable pipeline of projects, early collaboration with investors, and the deployment of innovative financial instruments can help cities take advantage of funding opportunities available from the private sector. This guide explores these topics in depth.
- **How Cities can Encourage Private Sector Adaptation Finance (C40, 2022):** looks at how cities can encourage businesses to assess their risks and invest in adaptation, develop an enabling environment for infrastructure investments, and explore private financing instruments.

- **Demystifying Adaptation Finance for the Private Sector (UNEP, 2016):** introduces relevant actors in adaptation financing, various financial instruments, and approaches to mobilizing the private sector for CCA.

Nature-Based Solutions

- **Guide to Living Terrace Roofs and Green Roofs (C40, 2015):** Barcelona has produced a guide to living terrace roofs and green roofs to explain the steps that the city has taken to support the transformation of unused roofs. The environmental benefits and technical advice laid out in the guide is nearly universally applicable to cities around the world.
- **Policy Activation Brief, Fostering Urban Biodiversity through Local Actions (ICLEI, 2020)**: provides local governments with a list of solutions and best practices to foster urban biodiversity. In the context of urban heatwaves, many of these suggestions can help provide nature-based cooling relief to city residents.
- **10 Protocols for Nature-based Solutions Implemented in Urban and Peri-Urban Areas (CityAdapt, 2024):** In collaboration with UNEP, the CityAdapt project has published a comprehensive guide on 10 specific nature-based solutions for urban areas, providing practical advice on how to implement them and an approximate breakdown of their various costs and inputs.
- **Nature-Based Solutions: How Cities Can Use Nature to Manage Climate Risks (C40, 2021)**: provides advice for how cities can implement nature-based solutions to build climate resilience. Leaning on case studies for support, the article discusses how to conduct a climate risk assessment, design blue and green infrastructure that responds to local hazards like extreme heat, and secure financing from both the public and private sectors for nature-based solutions.
- **Nature-based Solutions for Climate Resilient Cities (UNEP, 2023):** draws on perspectives and experiences from Latin America to outline how enhancing the function of natural ecosystems can foster climate resilient urban development.

Annex 2 – Additional Practical Examples from Cities

This section provides additional practical examples from cities in addressing urban heat risk, categorized into solutions for 1) Rethinking urban design and planning and 2) Extreme Heat Response.

1. Rethinking Urban Design and Planning

1.1. Built Environment

Austin, USA

Austin's municipally owned electric utility provider, Austin Energy, offers **centralized cooling plants** and **underground chilled water network pipes** to provide district cooling services to multiple residential complexes, a hospital, hotels, and a grocery store all at once. A single plant can meet the cooling needs of several buildings, reducing peak electricity demand, while also combating urban heat by reducing heat waste from individual cooling units.

Sources:

- C40 Cities Climate Leadership Group (2021b) Neighbourhood Level Cooling: Experiences from C40's Cool Cities Network. https://www.c40knowledgehub.org/s/article/Neighbourhood-Level-Cooling-Experiences-from-C40s-Cool-Cities-Network?language=en_US

Freetown, Sierra Leone

In Sierra Leone's capital of Freetown, 60% of the city's 1.2 million residents live in makeshift housing made of mainly corrugated iron roofs and walls that in the face of warming global temperatures and the region's equatorial climate turn the city into an open-air oven for most of the year. In fact, 99% of Freetown's built areas have been constructed using materials with low surface reflectivity, exacerbating the UHI effect such that average temperatures during the summer hover dangerously around 29°C. To address this urban heat stress, Eugenia Kargbo was named the city's **Chief Heat Officer** in 2021, a position funded by the Arsht-Rock Resilience Center and the first of its kind in Africa. Kargbo and the Freetown City Council have since installed **shade covers** to protect 2,300 street vendors, mainly women, in three major open-air marketplaces. These shade covers are **not only made from heat-reflective plexiglass but also include solar panels that power streetlights during the night**, allowing the women vendors to extend their working hours. Kargbo and the City Council have also implemented a **cool roofs pilot program** in the informal Freetown settlement of Kroobay where they are coating the roofs of 55 homes with **reflective film to reduce indoor temperatures**.

Photo: Reflective shade covers in the Congo Market of Freetown.

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Guangzhou, China

The Yongqingfang II pilot project has used a combination of **ancient and modern cooling** techniques to build the UHI resilience of old town Guangzhou. In order to preserve the historical style of the area, officials have focused on refurbishing and remodelling structures with **old Lingnan architectural cooling devices like arcades, balconies, flexible doors, double-layered tile roofs, and courtyard layouts**. They simultaneously installed **modern building façade mist sprays and cool roofs** as well. China-Singapore Knowledge City, on the other hand, is a new town in eastern Guangzhou planned in collaboration between China and Singapore. Unlike the traditional Ming Dynasty cooling methodologies used in old town Guangzhou, the China-Singapore Knowledge City pilot project has focused on integrating more modern cooling strategies such as **urban geometry** that streamlines wind circulation and cooling.

Photo: Modern building façade mist sprays in Guangzhou's old town.

Sources:

- Wang, X. (2023). Piloting Nature-Based Urban Cooling Solutions for Urban Regeneration and New Town Development in Guangzhou, China : Building a Cooler Guangzhou. World Bank Group. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/099023202092310085/1800310RPT0REV0d0Knowledge0City0v04
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Hong Kong, China

Hong Kong is building a second central business district on the site of the old Kai Tak airport. However, this new Kai Tak development will be entirely supported by a **district cooling system that uses seawater** from the surrounding Kowloon Bay. Not only is this system 35% more energy efficient than standard air conditioning units but the switch from traditional HVAC units to a district cooling system also reduces the UHI effect.

Photo: Kai Tak's district cooling system using seawater from the Kowloon Bay.

Sources:

- C40 Cities Climate Leadership Group and Nordic Sustainability (2019a). Cities100 2019 Report. https://www.c40knowledgehub.org/s/article/Cities100-2019?language=en_US

New York City, USA

Cool Neighbourhoods NYC is a citywide effort to tackle extreme heat launched in 2009. The program has since coated more than 10 million square feet of **rooftops with reflective white paint** and between 2007 and 2016, the NYC Department of Transportation **converted over 3 million square feet of dark asphalt roadbed to lighter-coloured or planted alternatives**.

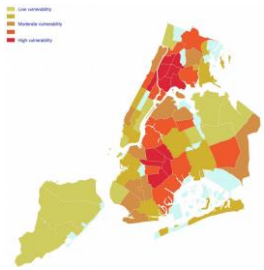

Photo: NYC's Heat Vulnerability Index

Sources:

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Los Angeles, USA

'Cool Streets LA' is a neighbourhood-level project that combines several cooling strategies to help combat the UHI effect. The city has competed 'Cool Streets LA' in five neighbourhoods, planting **new street trees**, installing **cool pavements**, installing **shaded bus benches**, and building **new hydration stations**. In the next implementation phase, 60 miles of new **pavement will be coated with cool slurry product**, and 600 sites will be planted with new trees. This next phase will cover an additional eight LA neighbourhoods.

Sources:

- C40 Cities Climate Leadership Group (2021b) Neighbourhood Level Cooling: Experiences from C40's Cool Cities Network. https://www.c40knowledgehub.org/s/article/Neighbourhood-Level-Cooling-Experiences-from-C40s-Cool-Cities-Network?language=en_US*, 15.*

Paris, France

As heatwaves pose an increasingly severe threat to Parisians, including one in the summer of 2019 that killed 1,500 people across France, Paris city officials are working to facilitate an interlinked network of 800 **cool islands** where residents and visitors can escape the heat. Made up of parks, swimming pools, museums, and more, Paris's goal is to ensure that all residents are within a seven-minute walk of a cool island or the naturally cool walkways that connect these sites.

Photo: One of Paris's 800 interlinked cool islands.

Sources:

- C40 Cities Climate Leadership Group and Nordic Sustainability (2019c). Cities100: Paris Is Using Blue and Green Infrastructure to Tackle City Heat. https://www.c40knowledgehub.org/s/article/Cities100-Paris-is-using-blue-and-green-infrastructure-to-tackle-city-heat?language=en_US

Singapore

Singapore's wealth and central planning system has allowed the city to quickly mobilize resources towards sustainable infrastructure projects. To avoid the creation of urban heat canyons, new development projects make use of **cooling urban geometry** like variations in buildings' heights and V-shaped breezeways. **Cool paint pilot projects** are also being rolled out in residential buildings to repaint roofs white in order to reflect heat. The success of Singapore's centralized planning model is most visibly evident in the Marina Bay neighbourhood, which was planned entirely from scratch. Instead of cooling small spaces with individual air conditioning units leading to massive amounts of heat waste, 23 buildings are cooled together by a **district cooling system**.

Sources:

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1.2. Nature-Based Solutions

Athens, Greece

Athens has the lowest per capita green space of any European Union city and is the hottest mainland European Union capital. To rectify this, officials have set a target to **create 25% more green space** across the city. For example, 14 schools have been retrofitted with **green roofs**, the ancient monument known as Hadrian's Aqueduct is being remodelled to irrigate a 24km **green corridor**, and there is an ongoing project to **restore 24 fountains** that were previously deactivated. At the center of this nature-based effort to cool the city is the Lycabettus Hill Sustainable Water Management program aimed at revitalizing the popular **urban forest and its waterways**. Ellinikon International Airport and its waterfront are also now being transformed into a 600-acre **park that will act as a sponge**, absorbing excess water and increasing cooling during heatwaves.

Sources:

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Barcelona, Spain

Created via a bottom-up public participation process, Barcelona's Climate Action plan aims to put the city on track for carbon neutrality by 2050. Given its formulation process, the plan is heavily people oriented. For example, given citizens' concerns about the dangers of heatwaves, the plan supports the increasing of **public green space** by 1 square meter per person so that eventually no one is more than a five-minute walk from a cool public space. Barcelona's Master Plan for Trees also establishes four goals for 2037: increase **total tree cover** by 5%, ensure that 40% of **tree species** are adapted to climate change, achieve a **biodiverse tree heritage**, and provide the public with information on the services that urban trees provide.

Sources:

- C40 Cities Climate Leadership Group and C40 Knowledge Hub (2021). Nature-Based Solutions: How Cities Can Use Nature to Manage Climate Risks. https://www.c40knowledgehub.org/s/article/Nature-based-solutions-How-cities-can-use-nature-to-manage-climate-risks?language=en_US
- C40 Cities Climate Leadership Group and Nordic Sustainability (2019a). Cities100 2019 Report. https://www.c40knowledgehub.org/s/article/Cities100-2019?language=en_US

Buenos Aires, Argentina

Buenos Aires is transforming its urban landscape by converting landfills into new blue and green spaces. Lago Lugano is a prime example of this initiative. Formerly a landfill, this **new nature reserve** includes a 20-hectare lake and 16 hectares of regenerated green spaces. Located in one of the city's main urban centers, Lago Lugano provides a cool respite for residents to escape the heat.

Photo: Lake Lugano in Buenos Aires, which has recently been converted from a landfill into a nature reserve.

Sources:

- C40 Cities Climate Leadership Group and Nordic Sustainability (2019a). Cities100 2019 Report. https://www.c40knowledgehub.org/s/article/Cities100-2019?language=en_US

Freetown, Sierra Leone

Freetown is expected to continue to undergo rapid growth in the future with the city's population projected to explode to 2 million by 2030. However, this trend of unsustainable urbanization has come at a steep cost to the area's green spaces where an equivalent of 12% of total canopy cover was lost per year between 2011 and 2018. To address the connected issues of diminishing greenery and urban heat, **"FreetownTheTreeTown", an unconventional tree-growing campaign** was spearheaded by the city's **Chief Heat Officer** Eugenia Kargbo. By uploading photos to the **TreeTracker app**, Freetown residents can document their planting of seedlings and monitor the growing process. Upon verification of the photos, they then receive mobile micropayments for their efforts. This **decentralized model of sustainable development** has been a massive success thus far. In the initial 2021 phase, planters successfully **planted and tracked 250,000 trees** and through partnerships with 10 commercial tree nurseries and 10 community-based organizations, the initiative created more than 550 short-term jobs. Currently, the city is on track to plant **7 million trees by 2030** while achieving an 80% tree survival rate.

Photo: The TreeTracker app's tree monitoring dashboard being used to collect data on Freetown's tree population.

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Guangzhou, China

The Guangzhou 2035 Master Plan, which focuses largely on carbon neutral development, also calls for the construction of a blue-green infrastructure network that connects and **conserves the 9 major ecological areas** of the city via **6 ventilation green corridors**. The Yongqingfang II pilot project has led to the implementation of **vertical and rooftop greening** in selected areas of old town Guangzhou. At a landscaping level, officials have leaned on the **planting of banyan trees** to provide cooling shade while maintaining the cultural memory of this historic district. The China-Singapore Knowledge City pilot project focuses on implementing international, modern best practices in a newly constructed town. Using the neighbouring Jiulong Lake and Laohulong Reservoir as natural cooling sources, city officials plan to build **a linear park** between these two bodies of water to amplify their effects. There are also plans in place to implement standard nature-based solutions such as **green roofs**.

Sources:

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London, UK

In 2019, London became the world's first national park city. This process involved spending more than $8.5 million to create or improve 175 hectares of **green infrastructure** and plant more than 175,000 **trees**. In support of the development of blue and green spaces in the city, London has also become the first place to apply a city-wide **Urban Greening Factor**. This new planning rule means that developers must quantify how they are contributing to greening in new developments and meet a certain baseline standard. This rule is being paired with a Green Infrastructure Focus map, which provides open access to high-resolution spatial data of London's **tree canopy, blue, and**

green cover. Together, these two tools enable developers to identify areas of the city which need improvement.

Photo: Vertical greenery in London, the world's first national park city.

Sources:

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Manchester, UK

Though located in a cooler and more temperate climate than much of England, Manchester still faces challenges regarding urban heat with temperatures rising over 37°C for the first time in July 2022. To combat similar climate risks, the city declared a Five-Year Environment Plan in 2019 with an aim of achieving carbon-neutrality by 2038. This decarbonization process involves a series of nature-based solutions, among other built measures, that have the interrelated benefit of reducing the impacts of heat stress. For example, **the Manchester City of Trees program**, which was started under the general scope of the Five-Year Environmental Plan, has committed to planting 3 million trees for each Greater Manchester citizen within a five-year period.

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- MCR2030. "Flames of Change: Innovating Heat and Wildfire Governance for Inclusive Communities," 28 March 2024. http://www.undrr.org/publication/flames-change-innovating-heat-and-wildfire-governance-inclusive-communities

Medellín, Colombia

To address severe urban heat challenges, the city implemented a 'greener Medellín for you' program. Since 2016, the heart of this $16.3 million program has been the creation of 30 **'Corredores Verdes' or green corridors**, an interconnected network of green spaces across the city. 75 citizens from low-income or disadvantaged backgrounds were trained by the Joaquin Antonio Uribe Botanical Garden to become **city gardeners**. In turn, they have organized the planting of 8,800 trees and palms in the 30 corridors, covering 65 hectares. The program, thus far, has been a massive success, already reducing Medellín's urban heat island effect by 2°C. Officials expect a further decrease of 4-5°C in the next 30 years.

Photo: One of Medellín's 30 green corridors.

Sources:

- C40 Cities Climate Leadership Group and Nordic Sustainability (2019b). Cities100: Medellín's Interconnected Green Corridors. https://www.c40knowledgehub.org/s/article/Cities100-Medellin-s-interconnected-green-corridors?language=en_US

Mexico City, Mexico

Mexico City has developed a ten-year climate action program focused on harnessing natural resources to address the impacts of climate change. This program includes the use of plants and water to improve urban resilience to high temperatures. It also seeks to take advantage of urban spaces to develop green and blue infrastructure. The plan calls for the construction of **parks, wells and infiltration gardens, and artificial wetlands** in natural recharge areas to control and harness rainwater. These structures contribute to ecosystem-based adaptation. Mexico City also has a Green Infrastructure Special Program that acts as a participatory planning instrument for nature-based solutions. The program is founded upon four principles: connectivity, accessibility, functionality, and resilience. Several initiatives have been launched under the program, including 'Planting Parks', a 'Green Challenge' of **urban revegetation, river sanitation, as well as the creation of wetlands, pollinating gardens, and urban orchards**.

Photo: The planting of an urban garden in Mexico City.

Sources:

- UNDRR (2022b). Mexico City Focuses on Solutions and Scale. Making Cities Resilient 2030, 3 November 2022. https://mcr2030.undrr.org/news/mexico-city-focuses-solutions-and-scale
- Durán, D. (2023). Así se prepara América Latina para un futuro con altas temperaturas y sequías. Inforbae. https://www.infobae.com/america/medio-ambiente/2023/08/15/asi-se-prepara-america-latina-para-un-futuro-con-altas-temperaturas-y-sequias/

Recife, Brazil

The Recife 500 Years Plan is an urban planning initiative adopted by Recife City Hall with the aim of guiding the city's development until its 500th anniversary, which will be celebrated in 2037. The plan focuses on citizen-inclusive sustainable development projects, such as the creation of new **green spaces and public squares**, that encourage social interaction and combat threats such as urban heat and flooding. The project to restore Capibaribe Park, for example, is an important part

of the Recife 500 Years Plan and aims to **revitalize the banks of the Capibaribe River into a large linear park**. The park will reduce vulnerability to flooding by promoting natural drainage and stormwater management solutions and mitigate the effects of urban heat islands by making use of the riverbanks' natural cooling effects.

Sources:

- INCITI. Parque Capibaribe. Available at: http://inciti.org/projeto/parque-capibaribe/

São Paulo, Brazil

To combat urban heat, the city's Department of Environment launched the 100 Parks for São Paulo program in 2005. By 2012, the project had succeeded in establishing 100 **city parks** covering 90 million square meters. Now the city has focused its attention on facilitating blue infrastructure via the **revitalization of waterways**. One such targeted waterway for revitalization is the Riacho do Ipriranga.

Photo: São Paulo's revitalized Riacho do Ipriranga waterway.

Sources:

- C40 Cities Climate Leadership Group and Ramboll Foundation (2021). Heat Resilient Cities: Measuring Benefits of Urban Heat Adaptation. https://www.c40knowledgehub.org/s/article/Heat-Resilient-Cities-Measuring-benefits-of-urban-heat-adaptation?language=en_US

Seoul, Republic of Korea

Opened in 2005, the Cheonggyecheon stream is a 5.4km **green corridor** in the historic center of Seoul. The site of a multi-level, six lane expressway in the 1970s, it was redesigned into an **urban waterfront park** that not only has reduced noise and air pollution and revitalized biodiversity but has also reduced temperatures by 3.3°C to 5.9°C compared to parallel streets.

Photo: Seoul's Cheonggyecheon stream.

Sources:

- Institute for Transportation and Development Policy (2016). Revitalizing a City by Reviving a Stream. Development Asia: An initiative of Asian Development Bank. https://development.asia/case-study/revitalizing-city-reviving-stream

Singapore

The focal point of Singapore's fight against extreme heat is **urban forestry**. The city's Green Plan 2030 and City in Nature initiatives promise to allocate 1,000ha of **green space** within the next 15 years so that every residential building is within a 10-minute walk of a park. Moreover, the Landscaping for Urban Spaces and High-Rises scheme, first rolled out in 2009, has introduced more than 300ha of skyrise greening in new developments. **Vertical greenery and green roofs** have already led to reductions of 10% to 31% in energy cooling loads. Singapore has also focused simply on just building **more parks** such as the 250-acre "Gardens by the Bay." These large, new green spaces have since been connected by a network of **green corridors** to allow cool air to flow effectively through the city, reflecting the benefits of Singapore's extensive central planning capacity.

Photo: Vertical greenery attached to a building in Singapore.

Sources:

- Hui, P.S. (2023). Cool Solutions for a Hotter Climate: Tackling Urban Heat Island Effect with Innovation. World Bank Blogs. https://blogs.worldbank.org/en/sustainablecities/cool-solutions-hotter-climate-tackling-urban-heat-island-effect-innovation
- Robles, P., Holder, J. and White, J. (2023). How to Cool Down a City. The New York Times, 18 September 2023. https://www.nytimes.com/interactive/2023/09/18/world/asia/singapore-heat.html
- Singapore National Research Foundation (2017). Strategies for Cooling Singapore. https://www.c40knowledgehub.org/s/article/Strategies-for-cooling-Singapore?language=en_US

Stuttgart, Germany

To counter the worsening threat of extreme urban heat, which is predicted to double in Stuttgart in 2031-2060 compared to 1971-2000 levels, 39% of the city's surface area has been protected to **preserve natural greenery**. As of 2019, more than 300,000 square meters of **roofs have been greened** and 63 km of tram tracks have been planted with **oligotrophic grasses**. The city is also in the process of installing **new drinking fountains** and other elements of urban blue infrastructure.

Sources:

- European Climate and Health Observatory (2024b). Case Studies – Stuttgart: Combating the Heat Island Effect and Poor Air Quality with Ventilation Corridors and Green-Blue Infrastructure. https://climate-adapt.eea.europa.eu/en/observatory/metadata/case-studies/stuttgart-combating-the-heat-island-effect-and-poor-air-quality-with-green-ventilation-corridors

1.3. Addressing Data Gaps and Inadequate Institutional Capacity

Astana, Kazakhstan

In 2020-2021, Astana conducted a **comprehensive Disaster Resilience Scorecard Assessment** as a part of its participation in MCR2030. The assessment, along with further **gap analysis** that was

being conducted at the same time, revealed that the city severely lacked accessible green space. In 2022, Astana only had 14.8 square meters of greenery per resident, far less than the 50 square meters baseline set by the WHO. This **initial assessment period has directly informed the creation of a new city greenery charter** for Astana that is currently pending approval.

Sources:

- MCR2030. "Flames of Change: Innovating Heat and Wildfire Governance for Inclusive Communities," 28 March 2024. http://www.undrr.org/publication/flames-change-innovating-heat-and-wildfire-governance-inclusive-communities

Guangzhou, China

In the face of lucrative residential construction proposals, Guangzhou city officials have made use of **big data analysis** to **quantify the urban cooling effects** of the nearby Haizhu Wetland, revealing that this large natural ecosystem is preventing 0.25°C to 1°C of warming. The quantification of these impacts provides empirical support for the preservation of wetlands and other green spaces to combat the UHI effect.

Photo: Haizhu Wetland near Guangzhou.

Sources:

- Nootenboom, C., Lonsdorf, E., Remme, R., Griffin, R., Han, B., Wu, T., and Guerry, A. (2022). Assessment of Key Ecosystem Services Provided by the Haizhu National Wetland Park in Guangzhou, China. World Bank Group. https://documents.worldbank.org/pt/publication/documents-reports/documentdetail/099014002092387112/P17330609788af0b40b9180ae1db785357f

Kampala, Uganda

By 2050, the city of Kampala is expected to have a population of 10 million people, making it among the fastest growing cities in sub-Saharan Africa. In 2016, the city developed a Climate Change Strategy aimed at promoting low-carbon sustainable development. Realizing the dual purpose of trees in both mitigating carbon emissions and combating urban heat, officials conducted a **comprehensive citywide tree audit** to **determine the current number of trees and identify new areas that are significantly lacking in coverage**.

Sources:

- Singh, R., Arrighi, J., Jjemba, E., Strachan, K., Spires, M., and Kadihasanoglu, A. (2019). Heat Wave Guide for Cities. Red Cross Red Crescent Climate Centre. https://www.ifrc.org/document/heat-wave-guide-cities

Melbourne, Australia

In 2019, Melbourne installed six **microclimate sensors** in six different streetscapes, including areas of mainly exposed asphalt, good tree coverage, and good canopy cover in the form of awnings. The data collected allowed city officials to better **understand which types of cooling interventions are most effective** in different neighbourhoods of Melbourne. The data eventually revealed that trees have the largest impact on ambient temperatures by 2-5°C, demonstrating how accurate data analysis and visualisation can steer the planning of efficient UHI countermeasures. Building off the city's efforts to monitor microclimatic data, **Chief Heat Officers** Tiffany Crawford and Krista Milne have also begun promoting the platform **Cool Routes**. Developed **using spatial analysis and heat data**, Cool Routes considers the position of the sun, shade cover, and city architecture to provide the best walking or cycling routes that are protected from the heat. The website provides **a clear, visual map of the safest routes when temperatures spike**. Residents can select options for the coolest walking or cycling routes, offering more targeted recommendations to help people plan safer trips. It also **identifies green and blue infrastructural sites**, ranging from urban gardens to water fountains. By marking them along the route, it **helps users understand where they can stop for a cool, safe rest** on longer trips.

Sources*:*

- C40 Cities Climate Leadership Group (2021b) Neighbourhood Level Cooling: Experiences from C40's Cool Cities Network. https://www.c40knowledgehub.org/s/article/Neighbourhood-Level-Cooling-Experiences-from-C40s-Cool-Cities-Network?language=en_US
- City of Melbourne. Cool Routes. https://www.melbourne.vic.gov.au/cool-routes

1.4. Financing

Athens, Greece

The Resilience Strategy for Athens 2030 is anchored by a 55 million euro **loan from the European Investment Bank**. The loan includes a **natural capital finance facility** to support the design and implementation of four nature-based solutions: three green corridors and the Lycabettus Hill Sustainable Water management program.

Sources*:*

- C40 Cities (2016). Cities100: Athens – Heatwave Action Plan Protects Vulnerable Residents. https://www.c40.org/case-studies/cities100-athens-heatwave-action-plan-protects-vulnerable-residents/
- Gaitani, N., Spanou, A., Saliari, M., Synnefa, A., Vassilakopoulou, K., Papadopoulou, D., Pavlou, K., Santamouris, M., Papaioannou, M. and Lagoudaki, A. (2011). Improving the Microclimate in Urban Areas: A Case Study in the Centre of Athens. Building Services Engineering Research and Technology 32(1), 53–71. https://doi.org/10.1177/0143624410394518
- Myrivili, E. (2022). Building Urban Heat Resilience: The Athens Case Study. https://thedocs.worldbank.org/en/doc/9e5105a293323cddf54df62da2e9e862-0070012022/original/D-Athens-Heat-Case.pdf

Freetown, Sierra Leone

"FreetownTheTreeTown" is an ambitious, city-wide experiment in **decentralized climate adaptation financing**. Relying on an easily accessible smartphone app, the initiative empowers and incentivizes Freetown residents to plant, grow, and digitally track trees through a **"pay-to-grow" scheme**. Planters simply open the app, take a photo of the newly planted tree, attach the coordinates, and provide critical updates on its growth progress. Upon verification of the tree's

survival, planters receive mobile payments directly. However, while many of the startup costs of the program were provided by the World Bank, its continuation is being supported by **the conversion of trees that have been geotagged on the app into impact tokens that can be bought and sold on public and private carbon credit markets.**

Sources:

- Bah, S. (2023). How Africa's First Heat Officer Is Protecting Women in Sierra Leone. BBC, 10 November 2023. https://www.bbc.com/future/article/20231109-how-africas-first-heat-officer-is-protecting-women-in-sierra-leone
- Fisseha, T., Toya, A., Cowan, N.M., and Duma, L. (2021). #FreetownTheTreeTown Campaign: Using Digital Tools to Encourage Tree Cultivation in Cities. World Bank Blogs. https://blogs.worldbank.org/en/sustainablecities/freetownthetreetown-campaign-using-digital-tools-encourage-tree-cultivation
- NOAA Research (2023). Lessons from Heat Mapping in Two Tropical Cities. https://research.noaa.gov/2023/05/24/lessons-from-heat-mapping-in-two-tropical-cities/
- Peltier, E. (2023). The Saturday Profile: She Is Africa's First Heat Officer. Can She Make Her City Livable?. The New York Times, 6 January 2023. https://www.nytimes.com/2023/01/06/world/africa/eugenia-kargbo-chief-heat-officer-africa.html

Medellín, Colombia

The 30 'Corredores Verdes' or green corridors system in Medellín is a feat for **democratic budgeting**. Colombian legislation dictates that a part of cities' budgets, known as **participatory budgets**, are to be invested in projects that citizens help to select. The green corridors program was one such project selected by the citizens of Medellín in 2016.

Sources:

- C40 Cities Climate Leadership Group and Nordic Sustainability (2019b). Cities100: Medellín's Interconnected Green Corridors. https://www.c40knowledgehub.org/s/article/Cities100-Medellin-s-interconnected-green-corridors?language=en_US

Miami, USA

Green bonds are a form of low-cost capital raising that are increasingly accessible to cities. In 2017, Miami citizens voted in favour of issuing $400 million of **Miami Forever Bonds** to fund a number of public projects including sea-level rise prevention infrastructure and new urban green spaces.

Sources:

- C40 Cities Climate Leadership Group and C40 Knowledge Hub (2022). How Cities Can Encourage Private Sector Adaptation Finance. https://www.c40knowledgehub.org/s/article/How-cities-can-encourage-private-sector-adaptation-finance?language=en_US

New York City, USA

The New York City Energy Efficiency Corporation (NYCEEC) was established and endowed by the city in 2011 with an initial capitalization of $37.5 million. It has since financed nearly $100 million in clean energy projects including district cooling initiatives to reduce urban heat. NYCEEC's **initial endowment** has facilitated $96 million in **debt financing** and has attracted **additional capital from private and philanthropic sectors**.

Sources:

- UNEP (2021). Beating the Heat: A Sustainable Cooling Handbook for Cities. Nairobi. https://coolcoalition.org/beating-the-heat-a-sustainable-cooling-handbook-for-cities/

Singapore

Besides the city's preexisting wealth, Singapore's Green Plan 2030 has also facilitated several new pipelines for green capital raising. For example, to meet the targets of the Green Plan, Singapore's government announced in 2022 that they will issue $35 billion worth of **green bonds** by 2030.

Sources:

- Jones Day (2022). Overview and Impact of Singapore's Green Plan 2030. In the Climate Report Newsletters.https://www.jonesday.com/en/insights/2022/08/overview-and-impact-of-singapores-green-plan-2030

Toronto, Canada

The city of Toronto has taken a **decentralized, regulatory approach** to incentive incorporating greenery in urban design. The Green Roof Bylaw, passed in 2009, requires new buildings with a general floor area greater than 2,000 square meters to have green roofs of at least a certain size. Developers can opt for a smaller green roof but must in turn pay a $200 fine per square meter. In a similar decentralized fashion, **the funds collected from fines** related to the Green Roof Bylaw have been collected to support an Eco-Roof Incentive Program such that **rebates** can be offered to landlords or developers that install green roofs or cool roofs on smaller-scale projects or existing buildings.

Sources:

- C40 Cities (2018). City of Toronto's Eco-Roof Incentive Program and Green Roof Bylaw. https://www.c40.org/case-studies/city-of-toronto-s-eco-roof-incentive-program-and-green-roof-bylaw/

1.5. Community Engagement

Jackson, USA

Jackson, Mississippi is forecasted to experience temperatures above 35°C for 58 days per year by 2030. In Mississippi, where one in four people live below the poverty line, inequitable extreme heat is of particular concern. To combat this issue, the city of Jackson has partnered with local non-profits, universities, and residents to **identify and design sites to be converted into green spaces**. Jackson has since successfully created **heat maps** of the city and chosen three sites for this initiative along the lower-income Farish Street. The transformation of Farish Street will began in 2024, and through this **community-led project**, Jackson is helping to provide vulnerable populations with relief in the locations that they actually need it most.

Photo: Community planning of the Farish Street greening initiative.

Sources:
C40 Cities (2023). Going Green for a Cool, Healthy Jackson. https://www.c40.org/case-studies/going-green-for-a-cool-healthy-jackson/

Milan, Italy

The Air and Climate Plan approved by Milan's City Council in February 2022 lays out the city's strategy for dealing with air pollution, carbon emissions, and the urban heat island effect. An important pillar of this plan is **early and regular citizen engagement**. For example, the plan calls for the **creation of a Permanent Citizens' Assembly on Climate** made up of randomly sorted citizens that have both the ability to evaluate the city's actions and propose new ones. This would allow for Milanese administrators to better match the actual needs of residents.

Sources:

- MCR2030. "Flames of Change: Innovating Heat and Wildfire Governance for Inclusive Communities," 28 March 2024. http://www.undrr.org/publication/flames-change-innovating-heat-and-wildfire-governance-inclusive-communities

Paris, France

In the inner city of Paris, there is a distinct lack of green space, only 5.8 square meters per capita to be exact. The largely asphalt and concrete-constructed 656 schools and 115 high schools of the city presented an opportunity for transformation to reverse this shortcoming. The OASIS project (standing for openness, adaptation, sensitization, innovation, and social ties) is an urban heat management initiative that concluded its pilot phase in 2023 after the conversion of 10 Paris school yards into green or shaded spaces. The planning and implementation of this project placed a particular emphasis on **active community engagement**. Given that these spaces are primarily used by school children, **the redesign process was completed through a series of participatory activities with the children and their parents**. For example, through co-design workshops, the children who attend these schools engaged in discussions and even created simple illustrations and models of what they wanted the new spaces to look like. Moreover, to build a sense of ownership, certain structures were left partially incomplete. Then, during several co-making workshops, children and their parents were invited to participate in the completion of the construction by helping plant beds of flowers, construct tipee tents, and put the finishing touches on play equipment structures. After the success of the pilot phase, the project is being expanded to cover 130 school yards across the city.

Photo: The remodelled Jean D'Arc Elementary Schoolyard in Paris now includes significant canopy cover to provide heat relief.

Sources*:*

- Sitzoglou, M. (2023). OASIS Takes off! - Final Journal. Portico. https://portico.urban-initiative.eu/urban-stories/uia/oasis-takes-final-journal-5598

2. Extreme Heat Response

2.1. Early Warning Systems (EWS)

Ahmedabad, India

After 1,344 people perished in a devastating 2010 heatwave, Ahmedabad became the first city in India to launch a comprehensive heat action plan in 2013. The plan itself has four main strategies. Firstly, through the dissemination of **public educational messages** via media outlets, text messages, email, radio, and social media, the city hopes to build public awareness about how to protect against the risks that heat waves pose. Secondly, the plan initiated a **heatwave early warning system** in which the city will issue varying levels of alerts to the public once temperatures reach a threshold of 41°C. Thirdly, the plan calls for **capacity building among health care professionals** about heat-related illnesses via trainings and workshops to better prepare for extreme heat situations. Finally, in 2017 and 2018, Ahmedabad launched a **cool roofs pilot program** wherein white lime wash was applied to 3,000 low-income homes.

Sources:

- Ahmedabad Municipal Corporation (2019). Ahmedabad Heat Action Plan 2019. https://www.c40knowledgehub.org/s/article/Ahmedabad-Heat-Action-Plan-2019?language=en_US
- ICLEI South Asia (2023). Rising Temperatures, Rising Solutions: South Asia's Path to Heat Resilience. https://southasia.iclei.org/rising-temperatures-rising-solutions-south-asias-path-to-heat-resilience/
- Kutty, S., Velukar, M. and Salunke, P. (2021). Strengthening Heat Resilience in Cities – Insight from India. ICLEI South Asia. https://southasia.iclei.org/strengthening-heat-resilience-in-cities-insight-from-india/
- National Program on Climate Change and Human Health, and Cool Coalition Secretariat (2022). Report: Ahmedabad National Workshop on Health Sector Measures to Mitigate and Adapt to Impact of Extreme Heat. https://coolcoalition.org/workshop-on-health-sector-measures/

Athens, Greece

In the summer of 2022, a **new heatwave categorization methodology** in Athens was launched. By correlating meteorological and mortality data from the last three decades, an EWS was set up based off of this categorization methodology. The **EXTREMA Global app** offers real-time information about heat exposure, nearby cool-down spots, and cooler routes. It has also been integrated with the EWS to provide residents with heatwave categorization system alerts that are easily accessible on their mobile devices.

Sources*:*

- C40 Cities (2016). Cities100: Athens – Heatwave Action Plan Protects Vulnerable Residents. https://www.c40.org/case-studies/cities100-athens-heatwave-action-plan-protects-vulnerable-residents/
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- Myrivili, E. (2022). Building Urban Heat Resilience: The Athens Case Study. https://thedocs.worldbank.org/en/doc/9e5105a293323cddf54df62da2e9e862-0070012022/original/D-Athens-Heat-Case.pdf
- Williams, J. (2021b). How Athens Is Adapting to Climate Change. *The Earthbound Report*. https://earthbound.report/2021/08/10/how-athens-is-adapting-to-climate-change/

Santiago, Chile

Since designating a **Chief Heat Officer** in 2022, the city of Santiago has been implementing several measures to combat the increasing threat of climate-driven extreme heat and its associated wildfires and health risks. The city has introduced a **heat wave categorization system** based on a regional protocol for extreme heat that provides guidelines for safety measures, public alerts, and preparedness actions on hot days. Specifically, it uses a **tiered alert system** to categorize heat waves based on forecasted temperatures. For days when temperatures are expected to be 24°C or higher, the National Service for Disaster Prevention and Response issues alerts that range from "Green Alert" to "Red Alert." Each alert level corresponds to specific actions: on "Green Alert" days, authorities provide preventive care measures and guidance to the public, while on "Red Alert" days, they suspend outdoor activities and prepare healthcare facilities for a potential increase in heat-related illnesses. This system helps the local and regional governments to communicate risks effectively and take appropriate measures to protect public health. The protocol prioritizes vulnerable groups, such as outdoor workers, and includes initiatives like **air-conditioned ambulances and urban greening projects**, such as planting 30,000 low water consumption trees, to reduce surface temperatures and enhance the city's resilience to heat.

Photo: Informational poster on Santiago's tiered heat wave alert system.

Sources*:*

- Wallace, C. (2023). "'Me Muero de Calor": How Santiago Is Building Local Solutions for Extreme Heat. *Atlantic Council – Climate Resilience Center.* https://onebillionresilient.org/2023/04/27/how-santiago-is-building-heat-resilience/

2.2. Equitable Heat Risk Reduction

Barcelona, Spain

Faced with a lack of green areas or free space to develop new green areas, Barcelona has begun the process of transforming school yards across the city into **climate shelters for students**. School yards in Barcelona tend to be entirely concrete, increasing children's exposure to the dangers of extreme heat. In the 11 schools selected for the Climate Shelters project so far, 1,000 square meters of **vegetation has replaced concrete flooring**, 74 **trees have been planted**, and 26 new **water points have been installed**.

Photo: A typical school yard in Barcelona that is primarily constructed of heat-absorbing concrete.

Sources:

- Barcelona City Council. Climate Shelters in Schools | Barcelona for Climate. https://www.barcelona.cat/barcelona-pel-clima/en/climate-shelters-schools
- Cartalis, C. (2020). Barcelona's Pilot Project to Beat the Heat | Portico. https://portico.urban-initiative.eu/urban-stories/uia/barcelonas-pilot-project-beat-heat

Hanoi, Vietnam

From 18 to 21 July 2019, Hanoi was affected by extreme temperatures peaking at 47.5°C. Three days earlier, in response to early warnings from the Vietnam Institute of Meteorology, Hydrology, and Climate Change, **anticipatory early actions** were taken to set up **Red Cross cooling centres**. Particularly, this early action test focused on addressing vulnerable, low-income populations. **Slums were retrofitted with shading roofs and fans** while **cash was distributed to subsidize cooling-related utility bills.** 66.8% of visitors to these centres reported that they felt better after the visit, and 90% advocated for their reopening in future extreme heat conditions, reflecting the importance and success of these targeted early action procedures.

Photo: Cooling centre in Hanoi during the July 2019 heatwave.

Sources:

- German Red Cross (2019). Heatwave Early Actions Test in Hanoi. Global Heat Health Information Network. https://ghhin.org/resources/heatwave-early-actions-test-in-hanoi/

New York City, USA

Under One NYC, the city's comprehensive roadmap to resilient and sustainable development, a maximum allowable indoor temperature was set in residential facilities and supportive housing projects. Furthermore, the city has **integrated climate risk and heat health learning modules into the standard curriculum for home health aides**. The city has also invested $930,000 into the launching of 'Be a Buddy NYC', a buddy system between community organizations and vulnerable New Yorkers that **includes educational messaging and even door-to-door checkups** during emergency heat situations.

Sources:

- New York City (2017). Cool Neighborhoods NYC: A Comprehensive Approach to Keep Communities Safe in Extreme Heat. https://www.c40knowledgehub.org/s/article/Cool-Neighborhoods-NYC-A-comprehensive-approach-to-keep-communities-safe-in-extreme-heat?language=en_US

Ottawa, Canada

The city council of Ottawa passed a Heat and Smog Action Plan in 2004 that prioritizes the safety of heat-vulnerable populations as one of its main goals. During heat alerts, city officials have partnered with numerous community organizations to meet this goal. Some of these special programs include deploying vans through the Salvation Army to **offer cold water to the homeless**, **offering discounted movie tickets in low-income neighbourhoods**, and **assigning public health nurses to visit vulnerable populations** living in high-rises to ensure they have access to proper cooling facilities.

Sources*:*

- Health Canada (2012). Community Response to Extreme Heat Events in the City of Ottawa. Global Heat Health Information Network. https://ghhin.org/resources/community-response-to-extreme-heat-events-in-the-city-of-ottawa/

Phoenix, USA

In 2016, the city of Phoenix, Arizona, launched the 'We're Cool' initiative to mitigate the impacts of urban heat on vulnerable populations. Through this program **volunteers are connected with low-income households and the homeless** to support them during extreme heat conditions. For example, in 2018, 92 volunteers logged more than 220 hours of their time over ten days to help distribute drinking water and 8,000 cooling center maps.

Sources*:*

- Singh, R., Arrighi, J., Jjemba, E., Strachan, K., Spires, M., and Kadihasanoglu, A. (2019). Heat Wave Guide for Cities. Red Cross Red Crescent Climate Centre. https://www.ifrc.org/document/heat-wave-guide-cities

Pudahuel, Chile

Rising temperatures have forced Pudahuel to suffer from increasingly longer and severe droughts. These droughts have affected agricultural production, the public water supply, energy production, human health, and biodiversity, all of which in turn have contributed to food insecurity, poverty and worsening inequality. Pudahuel has focused its response efforts mainly on community preparedness and inclusion. Through the Pudahuel Community Education Network and the Pudahuel Joven Program the municipality **offers workshops, courses, and school programs to increase extreme heat preparedness capabilities among people with disabilities and children**. These trainings have ranged from simulation drills of wildfires and droughts to teaching simple prevention, preparedness, and response measures to vulnerable communities.

Sources*:*

- Cortés, M. (2022). Pudahuel: la inclusión como pilar y factor operacional para la RRD y la resiliencia de todos.

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[2] Amadora City Council (2024). Civil Protection. https://www.cm-amadora.pt/pt/protecao-civil

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