ORF OBSERVER RESEARCH FOUNDATION

BUILDING RESILIENT CITIES

Adapting to the Health Impacts of Climate Change

Vikrom Mathur and Aparna Roy

Editors

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Editors' Note

Vikrom Mathur and Aparna Roy

URBAN POPULATIONS AND city dwellers, particularly in low- and middle-income countries, are especially susceptible to the health impacts of climate change. Urban areas, with their dense populations, are more affected by extreme weather events and often have large populations living in insecure informal settlements where access to basic necessities like water, sanitation, and healthcare is limited. Even in high-income countries, cities face multiple non-climate-related stresses, such as ageing infrastructure, poor land use planning, and political challenges. The way cities are constructed—reducing vegetation, covering large areas with impermeable surfaces, and obstructing natural drainage—exacerbates the vulnerability of urban populations to climate change, making them more prone to heat-

waves, heavy precipitation, and other extreme weather events. There is an urgent need for better urban-focused research and the implementation of strategies to address these vulnerabilities, particularly as urban populations continue to grow. Without such actions, the health impacts of climate change in cities are likely to become even more severe.

In three sections comprising nine essays, this volume attempts to examine and address these issues. Section I, 'Framing the Challenge', explores the mechanisms that make cities especially vulnerable to climate impacts and examines why certain communities bear a disproportionate burden of these impacts. The essays in Section II, 'Climate Change and Health Outcomes', map the diverse climate-related health impacts on city dwellers, from heat stress to infrastructure-related hazards. Section III, 'Solutions: Healthy Cities', charts plausible paths forward, with the aim of making urban populations more resilient to climate change impacts.

Growing urban populations and climate change impacts necessitate informed, decisive action. It is our hope that this volume will serve not only as a comprehensive resource for researchers and development practitioners but also as a catalyst for transformative change. By bringing together diverse perspectives from the domains of public health, urban planning, and climate science, we aim to advance our understanding of these complex challenges and outline a course towards more resilient, equitable, and healthy cities for future generations.

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I

Framing the Challenge

Urbanisation and Climate Change: Shared Risks, Health Challenges, and Pathways to Resilience

Robin Fears, Peter F. McGrath, and Montira Pongsiri

CLIMATE CHANGE PRESENTS a fundamental threat to human health, with disproportionate adverse effects on vulnerable groups such as children, women, and the poor. Evidence of its worsening health impacts worldwide is rapidly accumulating,[1,2,3] and these effects are particularly pronounced in cities, which host more than half of the global human population and account for about three-quarters of energy-related greenhouse gas (GHG) emissions.[4]

While cities pose critical challenges for climate action, they also present opportunities for the implementation of cross-sectoral climate policies and local solutions.[5] For example, increasing green spaces in cities can help reduce the intensity of the Urban Heat Island (UHI) effect

and thereby reduce heat-related deaths.[6] (It should be noted, however, that UHIs may also provide protection against cold-associated mortality in some cities.[7])

There is considerable scientific evidence that highlight the drivers of urban climate effects on physical and mental health.[8] For example, climate change has been found to lead to extremes in temperature and higher temperatures, causing heat stress and other temperature-related illnesses and deaths. The combustion of fossil fuels, the primary cause of climate change, generates air pollutants such as particulate matter (PM 2.5), which is the strongest and most consistent predictor of mortality from long-term exposure to air pollution.[9]

Human health in cities is affected by socioeconomic status and features of the built environment, such as green spaces and public transit infrastructure. Climate change interacts with social determinants to affect and exacerbate adverse health impacts.[10] These interactions of climate change with social determinants of health include increasing mobility/migration, overcrowding in cities with poor sanitation conditions, and limited access to essential health services.

In cities, the main climate hazards are heat extremes, flooding (whether from storms, sea-level rise, or other causes), poor air quality, wildfires, increased rainfall (which heightens the risks of vector-borne and water-borne infectious diseases), and forced population displacement (exacerbating the risk of food insecurity and limited access to essential health services). Adverse impacts are often compounded by poor governance.

UHI intensity and other climate impacts on health vary between different demographic groups within city populations, with the most severe consequences observed in poorer neighbourhoods.[11] Moreover, risk pathways combine to worsen adverse health

impacts. For example, heat and pollution interact in multiple ways, including through the impact of high temperatures in altering the chemical composition of particulate matter, increasing its toxicity.[12] There is increasing need to adopt a systems-based approach to understand and prevent the multiple inter-related factors affecting vulnerability to climate change-related urban health impacts.[13]

Clarifying What Works for Solutions

Urban health challenges cannot be solved by action in the health sector alone. Both mitigation (reducing emissions) and adaptation (increasing overall resilience) solutions and their better integration are needed.[14] However, a mapping of available research has found that cities with the greatest mitigation and adaptation challenges, particularly in low- and middle-income countries (LMICs), are systematically underrepresented in the literature.[15]

Mitigation

Recent work by the Lancet Pathfinder Commission[16] collates the evidence on actions to mitigate GHG emissions that can also deliver near-term health co-benefits, such as from reduced air pollution, consumption of healthy diets, and increased physical activity. In urban settings, action includes increasing green space, improving transit infrastructure, and promoting active travel. However, research on the implementation of proposed solutions must consider the potential for inadvertent consequences. For example, the introduction of new green spaces could provide breeding grounds for mosquitoes that transmit diseases such as dengue. Furthermore, urban greening solutions may have adverse results in terms of social inequality associated with the gentrification consequences of greening initiatives that are not adequately considered.[17] Such complexities underscore

the importance of taking a systems-based approach to health that includes engagement with the local community to design solutions.

The transportation sector could be considered an example for mitigation agenda-setting because of its significant contribution to urban GHG emissions. A recent assessment in Africa[18] highlights the potential to decarbonise transportation while also promoting economic transformation. The enhancement of city public transportation systems through the development of mass rapid transit systems can contribute to the green economy; however, there has been insufficient policy attention paid to health in priority-setting for transportation despite its clear potential benefits to improve well-being.[19]

Adaptation

Progress on climate-health adaptation actions has been impaired by inadequate funding for scientific evaluation and the translation of research outputs to policy and practice. Additionally, challenges are posed by the heterogeneity of adaptation needs, coupled with the weak capacity of systems to cope. Real-world adaptation case studies can help in formulating evidence on effectiveness, thereby facilitating the sharing and upscaling of solutions.

In a recent project, the InterAcademy Partnership (IAP), together with Save the Children, issued a call for health adaptation case studies that adopted a Planetary Health Framework[a] to improve the health of populations and the state of natural systems on which human health depends.[20] Case studies on health impacts and potential solutions were encouraged to execute systems-based transdisciplinary research with a focus on vulnerable,

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[a] The Planetary Health Framework encompasses transdisciplinary, systems-based approaches to describing the interdependence of health of humans and the environment.

underserved groups such as women and children towards co-producing solutions for transformative change. A Science Policy Brief[21] was also prepared and launched at the UNFCCC COP28 in 2023 to enable the convergence of emerging conclusions for policymakers. Table 1 presents case studies related to urban heat and non-communicable diseases.

Table 1: Heat-Health (Non-Communicable Diseases) Case Studies in Urban Settings

Case Study Country	Scope	Lead Author (as stated in IAP[22])
India	Modelling adaptation and mitigation in response to heat/ air pollution	Limaye
Brazil	Correlating heat, air pollution, and health for evaluation of social determinants of urban risk	Saldiva
South Africa	Assessing heat-health threats among women and children in primary healthcare settings	Wright
Ethiopia	Mapping urban overheating hazards for targeted interventions	Eshetie
Malaysia	National and city strategies to address urban heat island effects on vulnerable populations	Kamaruddin
Pakistan	Using systems dynamics modelling to assess impacts of urban tree planting	Bassi

The following key points can be generalised from the conclusions of these city case studies:

- High heat levels, either indoor or outdoor, pose physical and mental health risks, particularly to children, the elderly, low-income households, and those with pre-existing medical conditions.
- High heat and pollution interact to exacerbate health effects (e.g., respiratory and cardiovascular).
- Innovative mitigation and adaptation strategies are particularly useful if developed at the city level and with local stakeholders, including urban greening; cool roof programmes; other heat-resilient infrastructure; UHI monitoring to clarify vulnerabilities and accountabilities; and collaboration between public health agencies, urban planners, environmental organisations, and communities.
- Enhancing public awareness of climate-related health risks must empower communities with practical tools to combat risks.
- City and national guidelines can and should integrate UHI solutions proactively into urban planning policies and healthcare responses.

In addition to these heat-health impacts, the IAP-Save the Children project included other urban climate-health themes, published in the source mentioned in Table 1, among which were the following:

- Flooding in Tamale, Ghana, with a focus on understanding and managing risk in vulnerable communities and working with end-users (the affected community, NGOs, local authorities) as active participants in research (Howard and Awuni). Participatory research was necessary to develop flood management strategies for equitable health benefits.

- Infectious diseases in Dhaka, Bangladesh, to conduct a behaviour intervention study for surveying and promoting local community awareness and action on dengue in urban and other population-dense settings (Rahman).
- Health systems strengthening in coastal municipalities in the Philippines, employing transdisciplinary, cross-sectoral approaches to health services training, interventions, and priority-setting for climate awareness and resilience (Guinto).

The Intersection of Climate Change and Other Urban Challenges

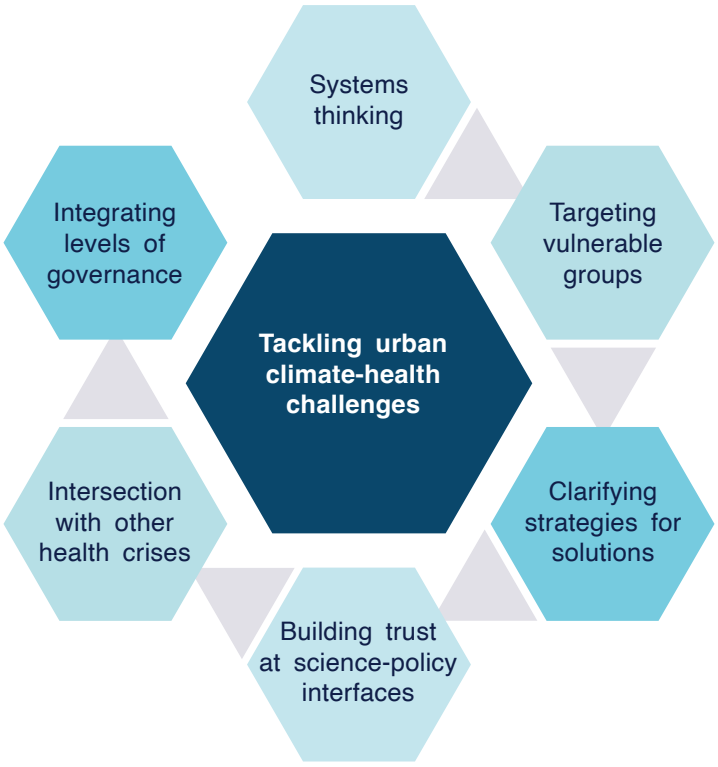
A collaborative project between the International Science Council, IAP, and the International Society for Urban Health yielded a conceptual framework for considering the multi-factorial, systemic nature of determinants and manifestations of health in urban populations. This collaborative project's assessment of the literature found that two-thirds of 2,600 cities were at risk from lack of resources and acute environmental or social stresses. The intersection of health crises was underscored by the convergence of threats from climate change and the COVID-19 pandemic.[24,25]

A 2022 IAP statement[26] on the implications of urbanisation in LMICs provides multiple recommendations relevant to health, some directly targeted to megacities—for example, to provide substantial investment in affordable and social housing (including the development of informal settlements), to monitor land uses in large metropolises to make them more compact, and to develop sustainable and efficient transportation systems accessible and affordable to all. Other recommendations from the statement can be considered relevant to all cities, such as planning to foster healthier lifestyles and greater reliance upon science-based approaches in urban and regional planning.

Action at Science-Policy Interfaces

Science-based urban policy options have recurrent themes (Figure 1).

Figure 1: Strategic Aspects of Relationships Between Policy Opportunities and Challenges in Urban Settings



Science Policy Brief[27]

From this science-policy interface assessment, we conclude that, in helping to clarify complex, dynamic interactions:

- Systems-based approaches are invaluable for researchers for identifying evidence gaps;
- Systems-based understanding helps policymakers identify the trade-offs and unintended consequences of different policy actions; and
- Understanding interconnections drives better integration of policy and practice across sectors and the different levels of action at the city, national, and regional levels.

Delivering added value for research, innovation, and policy also depends both on co-producing solutions with those most affected by climate change and combining goals for transformative change for health, equity, and environmental sustainability.

In the run-up to UNFCCC COP29 in November, the Baku Urban Partnership Process for Sustainable, Climate-Resilient and Healthy Cities provides new impetus for reimagining urban environments. While not wishing to pre-empt the COP29 strategic assessments and political agreements, we reaffirm twin objectives for urban health. First is the necessity to phase out fossil fuels; and second is a renewed commitment to delineating, funding, sharing, and upscaling evidence-based climate-health adaptation solutions, accompanied by broader action on structural issues to reform the currently unequal access to solutions.

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Resilience from the Margins: Protecting At-Risk Populations in Urban Environments

Soumya Swaminathan and Priyadarshini Rajamani

CLIMATE CHANGE, WHICH IS largely anthropogenic in nature, is posing critical threats to humans, with increasing temperatures, erratic weather patterns, rising sea levels, and the increased frequency of extreme events such as floods, droughts, and heat waves. The consequences of climate change, however, and their interlinkages with issues of health, livelihoods, and urbanisation—are disproportionately affecting the poor and marginalised.[1]

Urbanisation both affects and is affected by the local environment and the air, water, and food that people have access to. Rising carbon dioxide (CO2) and greenhouse gas emissions are leading to global warming, deforestation, and the loss of water bodies. Poor urban planning worsens

the urban heat island (UHI) effect, exacerbating heat impacts on those without access to cool spaces or air conditioning. Additionally, massive construction activities, sometimes over marshy land or over natural water channels, cause flooding during rains and water shortages in the summer.[2] Further, climate change negatively impacts infrastructure and essential urban services, especially during extreme weather events.

Globally, urban areas contribute about 71 to 76 percent of CO_2 emissions.[3] As centres of economic growth, cities attract people seeking jobs and better livelihoods, with rural livelihood loss—often due to climate change impacts like recurrent droughts—driving migration. However, due to poor infrastructure and economic disparities, cities become hubs of inequality. Over 1 billion people live in slums and informal settings, highly vulnerable to climate risks like extreme temperatures, floods, and heat waves. Urban temperatures are 3-5 degrees Celsius higher than in rural areas due to minimal green cover. Around 91 percent of the urban population breathe polluted air, and 40 percent lack sanitation and drinking water facilities.[4] Worldwide, 9 in 10 people breathe air below WHO standards.[5] More than 2 billion people still lack clean energy access, relying on biomass for cooking or heating.[6] This exposure to household smoke is especially harmful to women and children, resulting in respiratory, cardiovascular and metabolic diseases.

Gender influences exposure to extreme heat, with many women working in the agricultural and informal sectors. The most vulnerable groups include the elderly, pregnant women, infants and children, outdoor workers, and the poor.[7] Prolonged heat exposure can cause heat exhaustion and heatstroke, and exacerbate chronic conditions like cardiovascular and respiratory diseases. Marginalised populations, often without means to escape these conditions, face heightened risks. Many migrants reside in congested peri-urban areas that lack basic services like clean drinking water, sanitation, or green open spaces.

A 2023 review-based study highlighted that extreme temperatures damage both physical and mental health, imposing financial burdens on individuals, families, and communities.[8] However, gender-specific impacts of heat remain inadequately addressed in policy responses in the Global South, including India.[9]

Moreover, climate-related events such as flooding can contaminate water supplies, leading to outbreaks of diseases like cholera, typhoid, and dengue, which further strain health systems. While urban centres typically have more healthcare facilities than rural areas, resources are unevenly distributed. Marginalised communities face barriers like cost, distance, and discrimination in accessing healthcare, as well as mental health issues related to displacement and economic insecurity.

The 2024 World Economic Forum report projects that financial losses from extreme temperatures could reach US$2.4 trillion by 2030, even if global warming is limited to 1.5 degrees Celsius above pre-industrial levels.[10] Globally, over 2 percent of total working hours may be lost due to rising temperatures or due to employees operating at a slower pace because of heat. In South Asia and Sub-Saharan Africa, productivity losses could reach 5 percent.[11]

Building climate-smart cities and implementing co-beneficial measures are key to resilience. Urban planning must consider the UHI effects in housing and infrastructure design. Actions such as planting more trees and creating green-blue spaces would reduce UHI effects while promoting mental and physical health and reducing asthma and lower respiratory infections by improving air quality. Similarly, transitioning from fossil fuels to renewable energy, including in the health system, reducing the carbon footprint of buildings, improving public transport, having pavements for walking, increasing cycling and walking by increasing physical activity also positively impact health.

Efficient public transport reduces car use, increasing access to education, health, sexual and reproductive services. Cities with good public transport networks tend to have lower obesity rates and healthier populations.[12] Furthermore, blending traditional knowledge with modern scientific research has proven effective in designing buildings that adapt to local climates, offering culturally sensitive and ecologically sound solutions.

Urban planning and development policies should focus on building climate-resilient infrastructure in low-income areas, such as flood-resistant housing and improved drainage systems. Investments in green spaces can mitigate the UHI effect while also providing recreational areas that enhance the mental well-being of residents. Additionally, expanding access to affordable, quality healthcare is essential to ensuring marginalised populations receive timely care during climate-related health crises.

Key strategies include budgetary allocation, coordination and monitoring and evaluation. Given the nature of the crisis, new governance structures and mechanisms, including a nodal coordinating body at the city, district and state level might be needed. Targets for existing schemes aimed at women and children should be enhanced, and allocations increased to speed up the achievement of development goals, addressing the disproportionate impact of climate change on these groups.

Localisation and implementation of international climate action frameworks will be effective only if governments work closely with community-based organisations to ensure that adaptation plans reflect the realities on the ground. A bottom-up approach to planning climate mitigation and adaptation measures supported by political leadership at all governance levels is necessary for building resilience. This approach should create

spaces for community voices to influence policies affecting their lives, fostering a sense of ownership over adaptation processes. While marginalised communities face significant risks, they also hold immense potential for adaptation and resilience.

Climate action plans should promote synergy between climate change adaptation and health system strengthening. Achieving universal health coverage through comprehensive primary healthcare is the best way to improve population health and address the impacts of climate change and other threats. Additionally, private sector efforts can be leveraged and linked with government initiatives around gender-responsive climate action.

Climate financing should be part of the financial outlay of countries, especially of the relevant ministries. Health promotion and prevention should include not only curative healthcare but also empower communities to better cope with disasters, improve their quality of life, and prepare the health workforce to utilise the latest technology for better adaptation and mitigation measures.

All development actions—technologies, infrastructure, environmental health management, urban design—must now incorporate climate considerations and adapt accordingly. Artificial Intelligence and other digital solutions can be leveraged to provide both early warning of climate hazards and real-time advice on how and where to seek help and care.

More investment is needed in research and data for developing contextual solutions for developing countries. Long-term, multi- and interdisciplinary studies embedded in communities are needed to understand the holistic impacts of climate change on mental and physical health, social structures, livelihoods, migration, the role of women in society, and violence against women. Climate and health data should be analysed together, necessitating the creation of innovative data platforms.

Other climate actions should incorporate a gender lens, such as gender focal points in each ministry/department, gender-based budgeting, and enabling green job opportunities for women. Attention is also needed for other vulnerable groups like the elderly and disabled. Additionally, skilling young populations, fostering behaviour change, and investing in targeted solutions for climate migrants are crucial elements that should not be overlooked in designing climate change programs.

Addressing the root causes of vulnerability—such as poverty, social exclusion, and lack of access to education—is essential for building long-term resilience. Empowering marginalised populations with skills and knowledge for adapting to changing circumstances and diversifying their income sources enhances community resilience. By recognising and supporting the efforts of all citizens and implementing policies that address systemic inequities, we can pave the way for healthier and more resilient urban futures.

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II

Climate Change and Health Outcomes

From Heat Vulnerability to Heat Equity: Pathways for Inclusive Urban Climate Resilience

Nitya Mohan Khemka

IN 2008, FOR THE FIRST TIME in human history, more people globally lived in cities than in rural areas.[1] This global shift toward urbanisation, which began during the Industrial Revolution, has not only transformed how we live, build, and connect with each other, but has also fundamentally altered the earth's climate.

Cities are increasingly using materials such as concrete, which store more thermal energy than natural materials and absorb sunlight rather than reflecting it, warming their surroundings. This effect, amplified by heat from vehicles and industry, creates urban heat islands (UHIs)—city zones that are significantly warmer than neighbouring rural areas.[2] While the UHI effect currently averages between 2 and 4°C worldwide,[3]

this phenomenon is expected to intensify with worsening climate change. According to the IPCC's Sixth Assessment Report, global surface temperatures are projected to rise by anywhere from 1.4°C to 4.4°C by 2100 under various scenarios.[4] In urban areas, this warming will be amplified by the UHI effect, potentially leading to temperature differences of up to 8-10°C between cities and their surrounding areas by mid-century.[5]

Heat and Health

The direct heat effects on health range from heat exhaustion, as the earliest symptom, to cerebrovascular events and circulatory failures resulting in death. When exposed to extreme heat, living organisms are under constant stress to maintain their optimal temperature. This thermal balancing act—producing sweat and redirecting blood to the skin—forces the heart to work harder, potentially leading to cardiovascular failure. The strain extends to the respiratory and circulatory systems, raising the risk of both lung failure and stroke.[6] Without adequate access to water, the body quickly succumbs to dehydration.[7]

Most heat-related deaths are not caused by heat alone. Intense heat exacerbates numerous health conditions and impedes the effectiveness of medication, making its true threat to human life difficult to quantify.[8] However, heatwaves are consistently linked to peak mortality events.[9] Studies have estimated that UHIs may specifically contribute as much as 40 percent to heat mortality in European cities.[10]

Heat also has countless indirect effects on human health. Rising temperatures amplify air pollution, worsening its documented health consequences—particularly respiratory diseases.[11] Even young, healthy individuals struggle to regulate body temperature when exposed to high heat and humidity—a phenomenon known as the 'wet-bulb effect'.[12] Cities like Jacobabad in Pakistan

and La Paz, Mexico have already experienced dangerous wet-bulb temperatures, highlighting the urgent need for adaptation strategies that account for both extreme heat and high humidity.[13]

UHIs also disrupt local weather patterns, destabilising air flows and heightening flood risks.[14] UHIs are only expected to worsen as the global climate continues to change. In New York in the United States alone, the heat levels are projected to be two to six times higher in 2080-99 than in 1991-2004, resulting in 616 additional days of hospitalisation and US$644,069 of healthcare costs every year.[15]

Who Lives on a Heat Island?

Compounding the challenge is that the impact of extreme heat on health is not uniform; it is shaped by both biological and social determinants of health. While older people and those with chronic conditions face elevated risks everywhere, the socio-spatial distribution of heat vulnerability varies significantly between Global North and Global South contexts. A 2020 study in Delhi's informal settlements found indoor temperatures regularly exceeding outdoor temperatures by 3-5°C due to poor ventilation and construction materials.[16]

In rapidly urbanising cities of South Asia and Africa, informal settlements face particularly acute challenges. Heat exposure in informal settlements presents unique problems, particularly in Low- and Middle-Income Countries (LMICs), where large populations reside in dense, low-income housing with limited green spaces and poor ventilation.[17] For example, Mumbai in India experiences extreme UHI effects in its overcrowded neighbourhoods, with temperatures exacerbated by a lack of green infrastructure and high population density.[18] In Mumbai's slums, home to 40 percent of the city's population, extreme heat compounds existing health challenges from poor sanitation

and limited access to water.[19] Similarly, in Lagos, Nigeria, heat exposure is severe in unplanned settlements, where residents often lack reliable access to cooling solutions such as electricity or water for hydration.[20] These environments heighten health risks for vulnerable groups, including outdoor workers in informal sectors, such as street vendors and labourers, who face heat stress daily due to limited shade and hydration options.[21]

The occupational dimension of heat exposure is particularly significant in developing countries. In Ahmedabad, India, a study of outdoor workers found that 90 percent reported heat-related symptoms during peak summer months, with informal workers lacking basic protections such as shade or regular water access.[22] Similar patterns are seen among Bangkok's street vendors and Jakarta's construction workers, where economic necessity forces continued work during dangerous heat conditions.[23]

Understanding these inequalities is essential if interventions are to serve the people who need them the most. Yet, cities have historically relied on a flawed solution: designing urban spaces around universal air conditioning.[24] This approach is deeply problematic; air conditioning intensifies UHIs while increasing the energy consumption that drives climate change. Worse still, the majority of those who most need cooling, particularly in cities in the Global South, do not have access to the electricity required to power cooling solutions.[25]

Pavements and Roofs that Cool

Two types of measures can reduce UHIs: interventions in the built environment that reduce heat absorption and interventions that increase vegetation and thus evapotranspiration.

Cool pavements fall within the first category. These are paving materials that are more reflective than dark asphalt and

enhance evaporation. Cool pavements have been trialled in various contexts. In Doha, Qatar, cooling material applied to the asphalt of a road stretch in 2019 reduced the temperature of the asphalt by 7°C.[26] Cool pavements were trialled in Phoenix, United States, where an evaluation study showed that US$10-20 million in air conditioning costs could be saved every year if the whole city used the same construction materials for roads.[27] Cooler pavements also required less maintenance, reducing public costs and resource usage in the long term.[28]

The implementation of cool pavements extends beyond high-income contexts. In Hyderabad, India, the Cool Roofs initiative has adapted traditional white limewash techniques for modern urban conditions, reducing indoor temperatures by 2-5°C in informal settlements. Similar programmes in Bangkok have demonstrated that locally sourced reflective materials can achieve comparable cooling effects at lower costs than imported solutions.[29]

Conker Trees Instead of Concrete

Increasing urban vegetation offers a more holistic solution to combat UHIs. Unlike artificial cooling methods, plants deliver multiple benefits: they moderate temperatures while absorbing rainwater and carbon dioxide, reducing flood risks and air pollution. Trees, in particular, transform city life, boosting mental health, encouraging outdoor activity, and fostering community connections. Yet, access to these green spaces remains unequal, with disadvantaged communities typically having access to fewer parks and trees.[30] By greening our cities strategically, we can simultaneously tackle climate change, improve public health, and address environmental inequality.

One approach to urban greening involves creating extensive plant-covered spaces such as parks and cemeteries. In Medellín in Colombia, US$16.3 million was invested in developing 30 green corridors that link existing natural areas into a connected network. This initiative is projected to lower city temperatures by several degrees by 2030, potentially saving tens of thousands of lives from heat-related illness.[31]

Vertical forests, i.e., skyscrapers covered in greenery, can provide a more space-efficient alternative for densely populated areas. This concept, first tested in Milan in Italy, has now reached cities like Huanggang in China, where a single building absorbs 20 tonnes of CO_2 and produces 10 tonnes of oxygen annually.[32] While these vertical forests remain luxury projects today, their growing popularity could make them more accessible to less wealthy residents in the future.

The spread of vegetation throughout a city can be assessed by its tree canopy—the percentage of urban areas shaded by trees. While large-scale tree planting faces obstacles—notably the cost and carbon footprint of removing concrete—successful programmes can mobilise volunteer labour and empower community members to shape their local area. Chicago's Our Roots initiative adopted this approach to increase the tree canopy in underserved communities. Targeting neighbourhoods with tree coverage of 7 percent below the city average, the programme empowers residents to choose tree locations and participate in their care.[33]

In Chennai, India, the Green Ways project has transformed narrow urban lanes into green corridors, reducing local temperatures by 3-4°C while improving drainage during monsoons.[34] Jakarta's

Urban Forest initiative has converted abandoned lots into community-managed green spaces, particularly targeting flood-prone areas where vegetation can serve multiple resilience functions.[35]

Policies, Finance, and COP29

Cities have adopted several tools to combat rising temperatures, from cool pavements to urban forests, but these solutions demand a comprehensive approach. To be truly effective and economically sustainable, heat-adaptation strategies must be woven into city-wide policies that connect multiple systems: healthcare ready to respond to heat emergencies, early warning networks to alert residents, transportation designs that reduce car dependency, and architecture engineered for cooling. Yet, despite these possibilities, only one in three cities has integrated health into their climate-resilience plans.[36]

To effectively address the health impacts of urban climate initiatives, cities must gain recognition within international policy agendas and receive corresponding financial support. At COP27 in 2022, the Sustainable Urban Resilience for the Next Generation (SURGe) initiative brought together 180 cities.[37] Building on this, COP28 hosted an even larger Local Climate Action Summit, leading to the creation of the landmark *Guiding Principles for Financing Climate and Health Solutions.*[38] In anticipation of COP29, a Multisectoral Action Pathways (MAP) Declaration for Resilient and Healthy Cities has already been drafted, signalling an increasingly holistic, cross-sectoral approach to the health-climate nexus in urban contexts.[39]

However, while these developments are promising, uncertainty persists around funding. The International Finance Corporation (IFC) projects that cities could unlock up to US$30 trillion

in climate-related investments by 2030.[40] Although national governments appear the most likely sources to address the shortfall,[41] their fiscal capacities vary widely. To date, COP summits have struggled to mobilise significant solidarity funds for LMICs—those least responsible for, but most vulnerable to climate change.[42]

Cities currently receive very little climate finance from multilateral development banks (MDBs). The creditworthiness of cities is relatively low, and they face fiscal constraints from national governments. COP28 saw MDBs committing to increased climate finance, but their tendency to fund big infrastructure projects means that smaller city investments often do not reach their funding thresholds. Programmes such as the Green Cities initiative by the European Bank for Reconstruction and Development show that it is possible to finance comprehensive climate action plans at the sub-national level. A positive outcome of COP29 could thus be a commitment from more MDBs to adapt their operational systems to make their funds more accessible to cities.[43]

Conclusion

The intersection of climate change, health, and cities demands urgent attention, particularly in rapidly urbanising regions of the Global South. The use of innovative methods to improve urban design, safety, and well-being within cities has high potential.

However, these promising opportunities must not disguise the existential threat that climate change poses to cities worldwide. While our understanding of UHIs has improved considerably in the last decade, research is only now beginning to understand the interaction of heat and humidity levels and their repercussions for human health.

As we approach the next COP, strengthening urban preparedness for extreme heat is both urgent and essential. However, it is also critical to recognise that adaptation alone cannot fully shield cities from the impacts of climate change. The path to heat equity requires bold policy action: cities must revolutionise their approach to emissions control and environmental preservation to prevent catastrophic heat impacts on vulnerable populations.

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Malnutrition, Hunger, and Food-Borne Illness: The Growing Risks for the Urban Poor in a Changing Climate

Sara Roversi and Shoba Suri

CLIMATE CHANGE IS intensifying malnutrition risks, particularly for the urban poor, by heightening exposure to climate-induced droughts, supply chain disruptions, and rising food prices. Droughts are one of the most immediate and severe impacts of climate change, directly affecting food production. Climate-induced droughts reduce water availability, hinder agricultural productivity, and deplete essential crops, especially staple grains. Droughts now affect 55 million people globally each year, with the frequency of these events projected to triple by 2050.[1] Since 2000, the average number of droughts has increased by nearly 30 percent compared to previous decades, impacting food systems on nearly every continent.[2] According to the Food and

Agriculture Organization (FAO), around 14 percent of the world's food is lost before it even reaches consumers, primarily due to inadequate storage and transportation infrastructure.[3]

In 2022, urban poor populations in some parts of Africa and Asia reported increases in food prices of up to 50 percent following severe climate events that impacted transportation and logistics networks. From 2020 to 2023, the FAO's global Food Price Index rose by over 40 percent, with essential items like cereals, dairy, and vegetable oils seeing the steepest climb.[4] Economic shocks from the COVID-19 pandemic, the war in Ukraine, and climate-induced production losses have driven these increases, making it harder for low-income households to afford a balanced diet. Rising food prices reduce dietary diversity and force many low-income families to rely on low-cost staples rather than fresh fruits, vegetables, and protein sources. As a result, an estimated 42 percent of households in low-income urban areas worldwide experience food insecurity, with a marked increase in micronutrient deficiencies, particularly among children and pregnant women.[5]

Climate Change: Escalating Risks to Food Security and Safety

Globally, around 2.3 billion people face moderate or severe food insecurity, with urban poor populations disproportionately affected due to rising prices and limited access to diverse foods.[6] The United Nations (UN) reports that 9.2 percent of the global population live on less than US$1.90 per day, translating to millions of people vulnerable to malnutrition as food prices continue to rise.[7] Furthermore, marginalised urban communities often lack access to healthcare services and social safety nets, reducing their resilience to cope with these shocks. Without adequate support, malnutrition risks can become entrenched in these populations, perpetuating cycles of poverty and poor health.

As global temperatures rise, climate change also facilitates the spread of food-borne diseases, which pose additional health risks, particularly for the urban poor. The World Health Organization (WHO) estimates that 600 million people globally suffer from food-borne diseases each year, with 420,000 deaths resulting from consumption of contaminated food.[8] Rising temperatures increase the growth rate of pathogens such as Salmonella and E. coli, making food contamination more likely, especially in regions with limited food safety infrastructure, including clean water. Studies indicate that food contamination rates could increase by 20-30 percent in the coming decades due to climate-induced temperature rise, especially affecting urban areas in low- and middle-income countries where refrigeration infrastructure is limited.[9,10]

Focus on the Mediterranean Region

The Mediterranean region faces increasing climate challenges, significantly impacting food security, health, and economic stability. By 2030, temperatures in the region are projected to rise by 2.5-4°C, intensifying drought, accelerating soil degradation, and reducing water resources.[11] Spain's reservoirs, now at 25 percent capacity, highlight the strain on agricultural systems, with global warming contributing to 50-percent olive crop losses, a record surge in olive oil prices, and a 30-percent drop in Italian rice production. In some Mediterranean areas, climate change could reduce yields by 30 percent by 2050, and each additional 1°C rise in temperature will likely decrease crop productivity further. Rising food costs and persistent drought have also increased child malnutrition.[12] In drought-affected areas like France, the suicide rate among farmers facing crop failure is 40-percent higher.[13]

In response, Mediterranean cities like Barcelona have reduced emissions by up to 40 percent through investments in sustainable urban planning, renewable energy, and green infrastructure.

Experts advocate for integrating Mediterranean Diet principles[a] into urban food policies, which could cut the food system's environmental footprint by 72 percent.[14]

Scalable Frameworks for Building Resilience in the Face of Climate Change

The Integral Ecology Model

The Integral Ecology model, advanced by the Paideia Campus and the Municipality of Pollica in Cilento (Italy), blends public policy with local stakeholder actions to foster sustainable development. This approach recognises that human health is intrinsically tied to the environment, advocating for biodiversity, regenerative agriculture, and a lifestyle that aligns human needs with ecological balance—principles increasingly reflected in ESG reporting models that emphasise environmental stewardship, social responsibility, and sustainable governance.[15] Studies in the Cilento region highlight how community-oriented activities like shared meals improve mental well-being, reinforcing that social interaction and green spaces contribute to psychological resilience.[16] Furthermore, research shows that regenerative farming enhances soil health and boosts the nutritional quality of produce, an essential factor in adapting to climate change and maintaining healthy diets.[17]

Pollica's P.U.C.: A Model for Holistic Urban Development

Pollica Mayor Stefano Pisani's vision, "Eat well, be well, save the planet," is the philosophy behind the new Municipal Urban Plan

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[a] The Mediterranean diet was inscribed on UNESCO's Representative List of the Intangible Cultural Heritage of Humanity in 2013. It is recognised as a set of skills, knowledge, rituals, symbols, and traditions concerning crops, harvesting, fishing, animal husbandry, conservation, processing, cooking, and particularly the sharing and consumption of food. The diet emphasises values of hospitality, neighbourliness, intercultural dialogue, and creativity, and plays a vital role in cultural spaces, festivals, and celebrations throughout the Mediterranean basin. See: https://ich.unesco.org/en/RL/mediterranean-diet-00884.

(*Piano Uebanistico Comunale* - P.U.C.) “Food Scape” approved by the municipality, which goes beyond regulation to establish a holistic development framework. This vision is grounded in the belief that people cannot live healthy in a sick world, promoting ecological integrity as essential to community health and well-being.

The Mediterranean Diet: A Model for Sustainable Living

The ‘Mediterranean Way’ is a holistic approach to living that integrates environmental sustainability, cultural heritage, and public health. Research done by American physiologist Ancel Keys in Pollica, a town in Italy’s Cilento region, highlighted a lifestyle combining balanced nutrition, physical activity, and community engagement. His findings underscored a link between diet and reduced rates of chronic diseases such as heart disease, leading UNESCO to designate the Mediterranean lifestyle as a cultural heritage.

As climate change and public health challenges intensify, the Mediterranean Diet offers living, prioritising seasonal, locally sourced foods, community-oriented practices, and minimal environmental impact. These aspects are vital for urban resilience in climate-induced pressures, as they help support stable food systems and social cohesion. The Mediterranean Diet’s reliance on locally sourced, seasonal foods reduces dependency on long supply chains, fostering resilience. Traditional farming methods like water conservation and crop diversity stabilise production in Cilento, even under shifting climate conditions. Additionally, the diet’s preference for fresh, minimally processed foods addresses food safety concerns in warmer climates by lowering food-borne illness risks.[19]

Breaking the Cycle: Solutions to Mitigating Impact of Climate Change

Building Resilient Local Food Systems. Local food systems, which involve sourcing, producing, and consuming food within a community, offer a sustainable solution to combat the adverse effects of climate change on agriculture and nutrition. Agroecological practices, which integrate local knowledge with sustainable farming techniques, promote biodiversity and soil health.[20] Using drought-resistant crops, rotating crops, and adopting climate-smart agriculture (CSA) techniques can significantly improve yield stability in the face of unpredictable weather patterns.[21]

Strengthening Food Supply Chains. Investing in cold-storage facilities, improved packaging, and better transportation infrastructure can reduce food waste, especially for perishable items that are crucial for nutrition.[22] Governments and NGOs can collaborate to develop alternative distribution routes or strategies to prevent delays and spoilage.

Food Assistance Programs Targeted at Nutritional Security. Expanding food assistance programs tailored to urban poor populations can help improve access to affordable, nutritious foods, particularly during times of crisis.[23] This could include subsidised food distributions, community kitchens, and food vouchers, ensuring vulnerable groups have reliable access to essential nutrition.

Promoting Food Safety and Reducing Food-Borne Disease Risks. Strengthening food safety regulations, particularly for fresh and perishable goods, can help mitigate the risk of food-borne diseases.

Nutritional and Health Support Services. Scaling up access to healthcare, particularly for nutrition and infectious disease

management, is essential for vulnerable urban populations. This includes establishing mobile health clinics, subsidising essential medicines, and integrating nutrition support into urban health programs to address malnutrition and prevent food-borne diseases effectively.

Policy Interventions and Social Safety Nets. Expanding social protection systems, such as cash transfers and food subsidies, can buffer urban poor populations from the economic shocks of rising food prices, ensuring they maintain access to adequate nutrition and can respond to health emergencies without depleting their resources.[24]

Conclusion: A Blueprint for Resilience

Climate change disrupts weather patterns, causing perils to food production and global nutrition security. As climate-related events escalate, food systems become increasingly unstable, compromising food security and diet quality, particularly for vulnerable populations grappling with various forms of malnutrition. Urgent action is needed to shield food and nutrition security from mounting climate shocks, necessitating aligned leadership at the global and national levels. Preparedness, including contingency planning to support vulnerable populations, is critical. Moreover, concerted efforts towards resilience-building, and policy interventions are imperative to address these multifaceted challenges and promote sustainable development in a changing climate.

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Infectious Threats in a Changing Climate: Urban Vulnerabilities to Vector- and Water-Borne Diseases

Dinesh Arora, Benjamin Coghlan, and Vanshica Kant

BY 2050, AROUND seven billion of the global population, or nearly seven out of every 10 people, will be living in cities.[1] However, cities are increasingly emerging as global theatres of vector-borne diseases (VBDs).[2] Climate change is affecting the frequency, duration, and intensity of water-related extreme weather events, such as excessive precipitation and floods.[3] Contributing factors include rapid, unplanned urbanisation, warming temperatures, poor urban management, and sea-level rise.

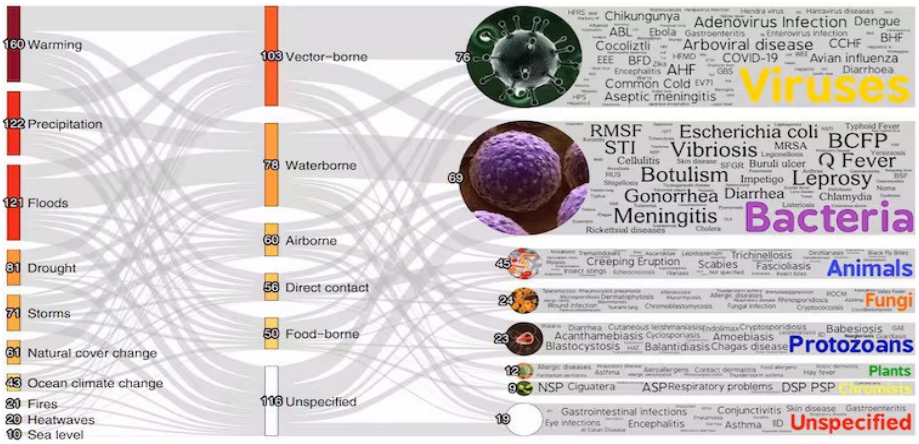
Urban flooding is the highest reported climate hazard in cities, with 92 percent of C40 cities experiencing flash or surface flooding in recent years.[4] Importantly, urban flood peaks are 1.8

to eight times higher than in rural areas, which, in turn, are reshaping geographic vulnerabilities and increasing the range and seasonality of VBDs.

The Rise of Urban VBDs

Climate hazards have exacerbated 58 percent of infectious diseases worldwide.[5] Notably, 60 percent of known infectious diseases, 75 percent of new or emerging infectious diseases, and five of the six public health emergencies of international concern have zoonotic origins.[6] The interactive map below lays out hazard and pathogen pathways.

Figure 1: Climate Change Hazard and Pathogen Pathways



Source: World Economic Forum[7]

The largest number of diseases aggravated by climate change involve vector-borne transmission, such as those spread by mosquitoes, bats or rodents, associated with atmospheric warming, heavy precipitation and flooding.[8] Table 1 shows a non-exhaustive snapshot of major VBDs globally.

Table 1: List of Major VBDs

Vector	Disease Caused	Pathogen Type
Mosquito Aedes	Chikungunya Dengue Lymphatic filariasis Rift valley fever Yellow fever Zika	Virus Virus Parasite Virus Virus Virus
Anopheles	Lymphatic filariasis Malaria O'nyong'nyong virus	Parasite Parasite Virus
Culex	Japanese encephalitis Lymphatic filariasis West Nile fever	Virus Parasite Virus
Aquatic snails	Schistosomiasis (bilharziasis)	Parasite
Culicoides flies	Oropouche fever	Virus
Blackflies	Onchocerciasis (river blindness)	Parasite
Fleas	Plague (transmitted from rats to humans) Tungiasis	Bacteria Ectoparasite
Lice	Typhus Louse-borne relapsing fever	Bacteria Bacteria
Sandflies	Leishmaniasis Sandfly fever (phlebotomus fever)	Parasite Virus

Sandflies	Leishmaniasis Sandfly fever (phlebotomus fever)	Parasite Virus
Ticks	Crimean-Congo haemorrhagic fever Lyme disease Relapsing fever (borreliosis) Rickettsial diseases (e.g., spotted fever and Q fever) Tick-borne encephalitis Tularaemia	Virus Bacteria Bacteria Bacteria Virus Bacteria
Triatome bugs	Chagas disease (American trypanosomiasis)	Parasite
Tsetse flies	Sleeping sickness (African trypanosomiasis)	Parasite

Source: World Health Organization [9]

The Lancet Countdown 2024 highlights the following VBD-specific evidence:[10]

- Dengue: The climatic suitability for the transmission of dengue by *Aedes albopictus* and *Aedes aegypti* increased by 46.3 percent and 10.7 percent, respectively, between 1951–60 and 2014–23.
- Malaria: Between 1951–60 and 2014–23, an additional 17.1 percent of the global land area became suitable for the transmission of *Plasmodium falciparum* and an additional 21.8 percent for the transmission of *Plasmodium vivax.*
- West Nile Virus: The temperature suitability for the transmission of the West Nile virus increased by 4.3 percent from 1951–60 to 2014–23.
- Vibrio: The environmental suitability for vibrio transmission reached a record high in 2023, with 88,348 km of coastline with waters suitable for transmission in 2023, up by 14.8 percent from the previous record in 2018.

The worsening of urban infectious diseases due to climate-related hazards can be linked to both direct and indirect mechanisms, with key factors including temperature rise, extreme weather events, and climate-driven migration. Gradual global warming creates favourable environments for disease vectors such as mosquitoes, rodents, and ticks by extending their range into previously unaffected areas. Warmer temperatures and altered rainfall patterns, which increase mosquito breeding sites, further heighten the risk of VBDs. Additionally, more frequent and severe weather events such as floods and contaminated drinking water supplies lead to outbreaks of water-borne diseases and population displacement, which further escalate disease-transmission risks among humans and animals. Climate-driven migration is another critical factor; as shifts in temperature and precipitation disrupt food and water availability, pushing people to relocate in search of resources and animal movement due to habitat changes, new pathogens are introduced to different areas, compounding the threat of infectious diseases.

The Health Impacts of VBDs in Cities

Outbreaks caused by extreme weather events and water contamination have the potential to cause extensive disease, particularly where public health infrastructure is less resilient.[11] Even high-income countries are not well prepared to cope.[12] There is also limited information available on how different water-related extreme weather events will impact different geographical areas and pathogens. Therefore, it is critical to establish the current impact of such events on public health to allow for future predictions, aid policy formulation, and improve adaptive capacity.

In 2022, an estimated 249 million malaria cases were reported across 85 endemic countries.[13] By 2050, areas not previously exposed to malaria will be at risk, resulting in a 50 percent higher chance of malaria transmission.[14] If carbon emissions

are uncontrolled and the planet's temperature rises by just 2-3 degrees Celsius, around 700 million more people could become vulnerable to malaria.[15,16] In the last two decades, the incidence of dengue has increased 10-fold, with reported cases increasing from 500,000 to 5.2 million globally.[17] An estimated 3.9 billion people in 129 countries are at risk of infection.[18] The WHO forecasts that, under a high-emissions scenario, climate change could lead to an additional 48,000 and 33,000 deaths from diarrhoeal diseases in children under age 15 by 2030 and 2050, respectively. Approximately one-third of the cases in 2030 and a quarter in 2050 are projected to occur in Asia, particularly South Asia.[19] Climate change poses a significant threat to cholera rates globally, especially in coastal regions such as Bangladesh and India, where incidence is highly sensitive to several factors.[20]

Socio-economic, gender, and age differences significantly affect the prevalence and impact of climate-vulnerable infectious diseases, influencing both exposure to various diseases and access to healthcare.[21] To address these issues, realising Universal Health Coverage—which is based on the principle that people have access to the full range of quality health services without financial hardship—and the One Health framework—which recognises the deep interconnections between human, animal, and environmental health—are vital.[22] As economic, political, and social centres, and given their large budgets, political will, and roles as centres of innovation, cities are well placed to protect people, animals, and the planet. Cities such as Rio de Janeiro, Bengaluru, and Kigali are leading diverse urban efforts to check the health impacts of VBDs.[23]

Cities at the Forefront of VBD Solutions

In 2023, the Climate and Health Initiative (CHI), established by the Asian Development Bank (ADB), was launched at the UNFCCC COP28 in UAE to deliver climate-resilient and low-carbon healthcare.[24] To mainstream the climate and health agenda, including around VBDs and zoonosis, ADB organised

the Climate and Health Solutions (CHS) India Conclave and the ADB-ADBI Policy Dialogue in Japan to galvanise stakeholders, build the political economy buy-in, mobilise investments, strengthen national capacities, coordinate development partners and accelerate innovations to check climate-induced infectious diseases.[25] Moreover, ADB, through the 'Ending Climate-vulnerable Infectious and Tropical Diseases (ExCITED)' initiative, aims to mobilise resources, accelerate innovations, and scale up health system preparedness to combat climate-vulnerable infectious and tropical diseases in the Asia-Pacific region and beyond. ADB plans to invest US$3 billion in the next three years, including in cities, towards achieving an outcome of strengthening and enhancing measures for ending climate-vulnerable infectious and tropical diseases.[26]

The Asian Development Bank is also exploring multiple interventions in urban centres to address the spread of climate-induced infectious diseases across developing member countries (DMCs).[27] Each focus area leverages different strategies and approaches—genetic, technological, environmental, and community-based, as follows:

- **Policy Advocacy:** Prioritising policies that align urban, health, and climate strategies to bolster disease mitigation and adaptation efforts to mobilise resources, support effective implementation, and track progress in controlling climate-sensitive infectious diseases.

- **Capacity Building:** Strengthening the capacity of cities, especially those highly affected by climate change, for resilient health systems and enhanced human resources to better manage climate-sensitive diseases.

- **Community Engagement:** Developing community involvement by supporting local health initiatives, awareness programs, and educational efforts for fostering

grassroots urban engagement against infectious diseases prevention and control.

- **Vaccines, Therapeutics and Diagnostics Manufacturing and Procurement:** Investing in research and development to expand the range and indigenous nature of medicines, vaccines, therapeutics and diagnostics and strengthening the supply chains.

- **Innovations in Disease Control and Diagnosis:** Mainstreaming innovations and digital solutions through city-level climate and health pilots and projects in urban jurisdictions and through catalytic financing of bold bets.[28]

    - **Genetic Modification of Mosquitoes**
      Example: Genetically modified (GM) mosquitoes reduce the number of disease-carrying mosquitoes by preventing offspring survival. GM *Aedes aegypti* such as the Oxitec mosquitoes in Brazil and the United States, have proven effective in decreasing mosquito populations.
      Impact: In Brazil, field trials demonstrate a reduction of up to 90 percent in Aedes mosquito populations, leading to lower transmission rates of dengue and Zika.

    - **AI Event-Based Disease Outbreak Monitoring**[29]
      Example: AI models can continuously scan large volumes of digital media in English and vernacular languages to track urban events and maintain a database to signal alerts regarding potential disease outbreaks.
      Impact: Media scanning has been a largely manual process in many Global South countries, involving thousands of newspapers and digital media outlets. This approach is a transformative process.

- **Drones and Geographic Information Systems (GIS) for Vector Control**
  Example: GIS mapping helps in identifying high-risk areas, and drones are being used to identify and treat mosquito breeding sites in inaccessible urban areas in countries such as Brazil and parts of Southeast Asia.
  Impact: By accurately targeting breeding sites, these technologies reduce vector populations more effectively than blanket approaches, particularly in large or remote areas.

- **Climate-Resilient Gender-Sensitive, Pro-Poor, and Low-Carbon Healthcare Infrastructure:** Upgrading urban climate-resilient health infrastructure and training municipal healthcare workers to respond to and manage extreme weather events and climate-sensitive diseases.

City-Level Surveillance and Early Warning Systems

Currently, most cities take reactive rather than proactive steps due to low engagement and investment in predictive and preventive capacities and systems. Information and action silos mean that there are limited platforms to collate information to rapidly see the big picture. Further, existing early warning systems provide little real-time, localised data and sensemaking due to an absence of action-focused data use. The Asian Development Bank, along with public, private, and civil society organisations, is working to scale novel city-level climate and health surveillance internationally.

The Philippines

Environmental surveillance is an emerging smart surveillance tool and non-clinical public health process by which environmental agents that produce or are expected to produce an adverse

effect on public health can be tracked, traced, and analysed to generate evidence for early warning systems or for adverse public health events.[30] It is a promising disease ecology method to complement both traditional, facility-based surveillance and newer digital epidemiology systems.[31]

Utilising environmental surveillance for a precision health experience through pilots is enabling the translation of evidence on climate-mediated and vector-borne health risks into action for the Tabaco city government in the Philippines.[a] The Precision Action Towards Climate and Health (PATCH) platform integrates and triangulates health, demographic, climate, and environmental data to provide actionable insights for municipal governments and stakeholders.[32] It offers end-to-end environment surveillance for data-based decision-making regarding climate-mediated health trends and risks and pathogen circulation and patterns to identify priority areas and mobilise resources in disaster-prone regions.[33]

India

Artificial Intelligence (AI) is being tapped to check for dengue by integrating meteorological forecasts, vector surveillance, socioeconomic data, and urban land use data for real-time analysis and data streaming through visualisations. The Dengue Dashboard, developed by the Artificial Intelligence and Robotics Technology Park (ARTPARK) at the Indian Institute of Sciences (IISc), includes interactive features, including hotspotting, to highlight districts at higher risk and age filters to track reported paediatric and geriatric cases.[34]

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[a] Besides the Philippines, environmental surveillance and data driven decision making in public health is being undertaken in India as well, namely in Bangalore, Lucknow, Jodhpur and Trichy by Swasti Catalyst.

This enables risk-classification forecasts for dengue outbreaks across districts and sub-districts up to four weeks in advance, allowing city-level leadership to strategically coordinate prevention and mitigation activities.[35] Till date, the Platform has streamlined dengue management for a population of over seven million.[36] The initiative is also expanding to other geographies and diseases, such as malaria, foot and mouth disease (FMD), and avian influenza.

Conclusion

Emerging innovations and digital solutions will be key to establishing environmentally sustainable vector- and pest-control policies and plans, expanding the scope of monitored diseases, establishing early warning systems, enhancing diagnostic and treatment options, and ensuring adequate animal and human vaccination coverage.[37] As the larger climate and health 'emergent ecosystem' grows, urban spaces will become the leading producers and consumers of emerging climate-health public goods.[b] Cities supporting the development and deployment of VBD-focused predictive analytics, vector-control innovations, climate-resilient infrastructure, and collaborative community-led initiatives will build a healthier and more resilient future for all.

[b] This refers to an ecosystem stage of growing recognition of risks, barriers, enablers breakthrough innovations and early solutions by decision-makers, funders, communities, and other stakeholders.

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Smog and Sickness: Urban Respiratory Health in a Warming, Polluted World

Sumi Mehta and Yasmine Yau

AIR POLLUTION AFFECTS 99 percent of the world's population.[1] Cities are on the front line of the climate and health crisis caused by air pollution, necessitating urgent action. A 2022 analysis found that 41 percent of the 7,239 cities studied have pollution levels seven times over the WHO recommended guideline levels for healthy air quality.[2]

Today, over half of the world's population live in urban areas, with this proportion projected to increase to two-thirds by 2050.[3] This increasing urbanisation, combined with global population growth and polluting activities, will put more people's health at risk due to exposure to air pollution.[4] The leading sources of emissions in cities include transportation, construction,

industry, waste burning, and power generation. In Africa, Asia, Latin America, and Eastern Europe, the biggest contributors to poor air quality in cities include biomass burning in homes and agriculture as well as wildfires. The primary source of air pollution worldwide is the burning of fossil fuels, which also releases greenhouse gases (GHG) and short-lived climate pollutants (e.g., black carbon) that drive climate change.[5]

Cities are facing more extreme heat events due to climate change, exacerbating the 'urban heat island' effect. This creates conditions for chemical reactions in the air that increase the formation of ground-level ozone, which further contributes to climate change.[6]

Health Impacts of Air Pollutants in Cities

Due to unequal exposure, the health burden is the heaviest on the most vulnerable populations, including young children, the elderly, and people with existing health conditions and those living in poverty. Air pollution increases the risk of pre-term and underweight babies, putting them at a developmental disadvantage that continues throughout their lives.[7] Air pollution affects infants' and children's developing lungs, putting them at a higher risk of deadly respiratory illnesses, including asthma and pneumonia. Globally, one child under five years old dies every minute due to air pollution.[8] Air pollution causes and exacerbates respiratory and cardiovascular disease among adults, including chronic lung disease, lung cancer, heart attacks, strokes, dementia, and diabetes.

Indeed, air pollution has become the world's primary risk factor for the global burden of disease. In 2021, air pollution caused 8.1 million premature deaths, overtaking tobacco as a major driver of disease.[9] PM2.5, the pollutant most damaging to health, caused 1.69 million deaths across 7,239 cities in 2019 alone.[10]

The health impacts of air pollution have global economic consequences, increasing illnesses, hospital admissions, healthcare expenditure, and lost working days, all of which slow productivity and economic growth. The World Bank estimates that the global cost of health damage from air pollution is US$8.1 trillion, equivalent to 6.1 percent of global GDP.[11]

Yet, this burden of disease from air pollution is not equitably distributed globally; people in South Asia and Sub-Saharan Africa bear the greatest brunt of illness and premature death due to fossil fuel-intensive development, urbanisation, and continued reliance on household biomass burning.[12] The pace of urbanisation is the fastest in lower- and middle-income countries (LMICs), and 97 percent of cities in these countries have unsafe levels of air pollution.[13]

Air Pollution and Climate Change in Cities

Air pollution comprises a mix of particles and gases, which vary across cities depending on the local environment, geographical features, meteorological factors, and human activities.[14] The main health-harming and climate-disruptive pollutants emitted in cities are fine particulate matter (PM2.5), which includes black carbon, commonly referred to as soot; nitrogen dioxide (NO_2); and ozone (O_3).[15]

Transportation, especially road vehicles, are a major source of urban air pollution and GHG emissions.[16] Many cities were originally planned with a focus on cars and roads, which has led to detrimental effects on public health due to accidents, congestion, and pollution.[17] City residents, particularly the poor, tend to live and work closer to busy roads and are often more exposed to higher levels of NO_2.[18] NO_2 irritates the airways and aggravates respiratory diseases, impairs lung development, and increases the risk that a child will develop asthma.[19] NO_2 reacts

with other chemicals in the air to form particulate matter and ozone, with warmer temperatures accelerating this reaction. An air-quality study found that 86 percent of cities exceed the WHO guidelines for NO_2.[20] Air pollution, in combination with extreme heat, increases the number of cases of stroke, heart attacks, and kidney failure. Additionally, exposure to ground-level ozone is associated with an increase in hospitalisations due to asthma and chronic lung diseases; increased ground-level ozone levels cause almost half a million additional premature deaths each year[21] and have far-reaching climate impacts.[22]

Cities as Agents of Change for Health and the Climate

Historically, climate mitigation approaches have focused on measures to reduce carbon dioxide emissions to avoid their long-term impacts. Air pollution and climate change share common solutions. Cities are leading the way to address both simultaneously while protecting health.

Replacing fossil fuels with cleaner energy sources will improve urban air quality and reduce climate-disrupting pollutants. City mitigation strategies include sustainable urban planning through the enforcement of clean vehicle standards, increasing green spaces and rewilding, improving the infrastructure for walking and cycling, and ensuring better waste management than incineration. These measures offer multiple co-benefits for health and well-being, such as better air quality, fewer extreme heat events, and increased physical activity.[23]

Air quality data is crucial to informing action at the city level. Extensive, reliable, and accurate city-level air-quality data, with an understanding of its sources and health impacts, are important for monitoring, reporting, and providing the evidence to inform decision-making to reduce emissions and create public demand for clearer air. Over 6,000 cities in 117 countries

monitor air quality and feed this information into WHO's air quality database.[24] However, more needs to be done to expand coverage, particularly of smaller and mid-size cities and those in LMICs.

Sustained, cross-sectoral, and multi-disciplinary collaboration is required to ensure successful reductions in urban air pollution, with public demand to inspire political will and leadership and resources to scale and strengthen more robust and effective clean-air action. Developing and implementing innovative solutions for both clean air and climate and ensuring that there is sufficient infrastructure in place to measure and demonstrate positive impacts will require greater commitment and investment, so that success can be achieved in more cities.

A number of global, national, and city-focused initiatives are working at the intersection of climate, air pollution, and health, including Breathe Cities,[25] the Climate and Clean Air Coalition,[26] the Partnership for Healthy Cities,[27] C40 Cities,[28] and the Clean Air Catalyst.[29] Working collaboratively with city leadership, these initiatives have tested solutions to reduce emissions from major polluting sources. Local governments around the world are implementing replicable clean air solutions that can yield benefits for the climate and for human health.

CleanAirforHealth.org[30] records successes from Accra (Ghana), Barranquilla (Colombia), Beijing (China), Jakarta (Indonesia), Kampala (Uganda), and New York City (United States), showcasing how engagement with public health organisations and health practitioners has accelerated solutions to tackle major sources of pollution to improve air, climate, and health. Moreover, these examples demonstrate how cities of different sizes and resources, with different air-pollution sources and differing levels of data and technical capacity have been able to prioritise and demonstrate effective clean air action (Figure 1).

Figure 1: Cities with Varying Concentrations of Air Pollution, their Sources, and Clean Air Action

City and Country	Population (millions)	Annual $PM_{2.5}$ Concentration	Leading Emission Sources	Solutions Implemented
Accra, Ghana	5.5	51.9 kg/m^3		Urban health initiative: engaging the health sector in transformative urban planning
Barranquilla, Colombia	1.3	15 p.g/m^3		Air quality management plan, included the restoration and expansion of green urban areas.
Beijing, China	21.8	30 p.g/m^3		Elimination of coal fired power plants and gas fired boilers. Household heating transition to electric or gas.
Jakarta, Indonesia	10.5	39 μg/m^3		Implementation of routine vehicle emissions compliance testing
Kampala, Uganda	5	39 p.g/m^3		Introduction of a car free day as a community health campaign
New York City, USA	8.3	8 p.g/m^3		Mandated the use of cleaner fuels for residential buildings
WHO Air Quality Guidelines Levels		5 ug/m^3		

Source: CleanAirforHealth.org[31]

The Breathe Cities initiative supports a growing network of cities around the world to improve air quality. The approach consists of expanding access to air quality data to inform the public and decision-makers, raising awareness to build public support for action, and providing technical assistance to cities

to identify, develop, and implement bold solutions, as well as sharing learnings across cities, as in the case of the 'Breathe Jakarta' interventions, which are aimed at ensuring residents can breathe cleaner air.

Figure 2: 'Breathe Jakarta' Interventions to Reduce Air Pollution

Source: Breathe Cities and CleanAirforHealth.org[32]

Targeted clean-air action around the world demonstrates how a focus on reducing emissions from leading sources of pollution can improve air quality, resulting in measurable benefits to respiratory and cardiovascular health. Similar efforts in cities around the world should be fostered to demonstrate a win-win for health and climate.

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The Mental Health Imperative for Global Climate Action

Nishant Sirohi

AS THE GLOBAL COMMUNITY gathers at COP29 in Baku to confront the pressing challenges of climate change, one critical issue demands urgent attention: the mental health impacts of climate change. While the world has largely focused on the physical and economic dimensions of the climate crisis, its profound effects on mental well-being are yet to be explored and addressed. The psychological toll of a warming world is mounting,[1] and unless we act decisively, the mental health impacts of climate change will compound existing vulnerabilities[2] and deepen inequalities,[3] especially for those in urban areas.[4]

The Hidden Crisis of Climate Change

Climate change is not just an environmental crisis; it is a human crisis that affects every aspect of our lives, including mental health. Extreme weather events, displacement, and chronic environmental stress are contributing to rising anxiety, depression, trauma, and grief.[5] Urban populations, particularly those in low- and middle-income countries, are at the forefront of this challenge.

Extreme weather events, such as heatwaves, storms, floods and wildfires, have immediate and long-lasting psychological impacts. These events disrupt daily life, displace communities, and lead to acute stress, anxiety, and post-traumatic stress disorder.[6] The psychological impact is more severe in cities where populations are concentrated and vulnerabilities are high.[7] For example, during heatwaves, emergency services see a spike in aggression, mood disorders, and mental health emergencies, highlighting the urgent need for climate-resilient urban planning.[8]

Beyond the immediate trauma of extreme weather events is the more insidious threat of chronic climate anxiety.[9] The looming threat of climate change, amplified by unpredictable weather patterns, rising temperatures, and environmental degradation, leads to pervasive feelings of fear, helplessness, and uncertainty. This climate anxiety is particularly prevalent among young people who worry about the future that they will inherit.[10]

The Psychological Toll of Displacement

Rising sea levels, repeated floodings, and extreme heat are pushing millions to flee their homes, particularly in coastal and flood-prone cities. Yet, displacement is not just about losing

a physical home; it is about losing a sense of place, identity, and community. The psychological impacts of displacement are profound; feelings of grief, loss, and dislocation can lead to depression, anxiety, and a diminished sense of belonging.[11]

Displaced populations often end up in precarious living conditions, with insecure housing and limited access to basic services. This precariousness creates ongoing anxiety and stress, especially for those in informal settlements where the risk of future climate impacts remains high.[12] The uncertainty of life after displacement, compounded by economic hardship and disrupted social networks, exacerbates mental health challenges and leaves individuals more vulnerable to future shocks.[13]

Environmental Stress: A Constant Burden

Chronic environmental stressors, such as rising temperatures, worsening air pollution, and the degradation of green spaces, have a profound impact on mental well-being. These stressors are particularly acute in cities, where the urban heat island effect, poor air quality, and loss of biodiversity create a daily strain on mental health.[14]

Heat stress, for example, is linked to increased rates of aggression, anxiety, and cognitive decline.[15] Poor air quality is associated with higher rates of depression and neurodegenerative disorders.[16] The loss of urban green spaces deprives city dwellers of critical areas for relaxation, social interaction, and stress relief.[17] The absence of nature in urban environments also contributes to a sense of alienation and disconnection, leading to higher levels of stress and anxiety.[18]

Vulnerable Populations at Greater Risk

Climate change does not affect everyone equally. Vulnerable populations, such as low-income groups, marginalised communities, the elderly, children, and indigenous peoples, are disproportionately impacted by the mental health consequences of climate change. These groups often lack the resources to adapt or recover, leaving them more exposed to the psychological impacts of a changing climate.[19]

In urban areas, informal settlements are particularly vulnerable. These neighbourhoods are overcrowded and have poor infrastructure, if at all, and the people have limited access to healthcare and face the double burden of social and environmental stress. Residents of informal settlements often experience higher levels of social isolation, discrimination, and economic hardship, all of which are risk factors that lead to poor mental health. For elderly residents and those with disabilities, the challenges are even more immense, as they are more vulnerable to heat stress, flooding, and social exclusion.[20]

Children are also acutely affected by the mental health impacts of climate change. Disruptions to schooling, play, and socialisation can have long-lasting psychological effects, leading to increased stress, anxiety, and developmental challenges. Young people, in particular, are grappling with ‘eco-anxiety’, a term used to describe the deep-seated fear of environmental collapse, arising from sense of responsibility and uncertainty about the future.[21]

Legal and Policy Gaps in Addressing Mental Health Impacts

Despite growing evidence of the impact of climate change on mental health, policy responses remain inadequate. International frameworks like the Paris Agreement and the Sendai Framework

for Disaster Risk Reduction recognise the importance of addressing climate risks but fall short of integrating mental health considerations into their strategies. This omission presents a significant gap in global climate governance.[22]

A rights-based approach is essential to closing this gap. The right to health, including mental health, is a fundamental human right that must be upheld in the context of climate change. Governments have a duty to protect vulnerable populations from the mental health impacts of climate change and ensure that mental health services are accessible to all. This requires a comprehensive framework that integrates mental health into climate adaptation, mitigation, and disaster risk reduction efforts.[23]

Building Mental Health Resilience in a Changing Climate

To address the mental health impacts of climate change, there is need for a multifaceted approach that includes robust health systems, inclusive urban planning, and a commitment to equity and justice. The following paragraphs outline some key strategies:

- **Integrating mental health into climate policy:** Mental health must be a central component of climate policy. National and local governments should include mental health considerations in their Nationally Determined Contributions (NDCs), national adaptation plans, and urban resilience strategies. This integration will ensure that mental health is prioritised in climate action and not treated as an afterthought.[24]

- **Building adaptive mental health systems:** Health systems need to be equipped to provide mental health support before, during, and after climate events. This includes training mental health professionals in disaster risk management, deploying mobile mental health units in vulnerable areas, and ensuring that mental health services are part of emergency response efforts.[25]

- **Promoting community-based interventions:** Community resilience is crucial to mental health adaptation. Locally led solutions, psychosocial support networks, and culturally relevant mental health interventions can help communities cope with climate impacts. Empowering communities to participate in adaptation planning can foster a sense of agency and reduce feelings of helplessness.[26]

- **Investing in green infrastructure:** Cities must prioritise green infrastructure, such as parks, urban forests, and green roofs, to mitigate the urban heat island effect and promote mental well-being. Access to green spaces has proven psychological benefits, contributing to reduced stress, increased social interactions, and a stronger sense of community.[27]

- **Protecting climate-displaced populations:** Governments should establish legal protections for climate-displaced populations, ensuring access to secure housing, healthcare, and social services. This includes recognising climate displacement as a human rights issue and developing relocation policies that are fair, transparent, and sensitive to cultural contexts.[28]

A Call to Action

The mental health impacts of climate change demand urgent attention. As we move forward in our fight against climate change, we need to recognise that mental health is a core element of human well-being and resilience; it is not merely a secondary issue. By integrating mental health into climate policy, investing in adaptive health systems, and prioritising vulnerable populations, we can build a future that is both environmentally sustainable and socially and psychologically resilient.

The time to act is now. At COP 29 in Baku, let us commit to a climate agenda that includes mental health as a fundamental pillar of resilience and equity. Our cities, our communities, and our future generations depend on it.

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III

Solutions: Healthy Cities

Framing Urban Design Strategies to Address the Health Impacts of Climate Change

Meelan Thondoo, Nina Abrahams, and Erin Mathieu

AS CLIMATE CHANGE intensifies, cities worldwide—particularly those in low- and middle-income countries—face increasing public health threats from heatwaves, flooding, and extreme weather, exacerbating existing health inequities.[1,2] The urban landscape influences health outcomes, especially as cities become hotspots for climate-related risks like extreme heat, worsened air quality, vector-borne diseases, and food insecurity.[3,4] To counter these challenges, urban design and planning must evolve to build cities resilient to climate-related health impacts.

Urban design and planning strategies must integrate climate resilience into public health,[5,6] addressing existing vulnerabilities, such as poor housing, limited healthcare, and insufficient green

spaces.[7,8] This approach necessitates proactive urban planning that balances immediate needs with long-term resilience, making climate adaptation in city infrastructure and public health services a critical priority.[9,10] This article explores strategies for developing climate-adaptive urban environments, focusing on green infrastructure, sustainable housing, and resilient public health systems to mitigate climate-related health risks.

The Role of Green Infrastructure

Green infrastructure uses natural systems, like trees, parks, green roofs, and wetlands, to address environmental challenges in cities, such as extreme heat, air pollution, and stormwater management.[11] These elements act as natural buffers while improving urban health and well-being.

Heat Mitigation

The urban heat island (UHI) effect,[12] where cities experience higher temperatures than surrounding rural areas due to heat-absorbing materials like asphalt and concrete, poses serious health risks,[a] particularly affecting vulnerable populations such as the elderly and children.[13] Incorporating green spaces can reduce the UHI effect by providing shade, lowering surface temperatures, and promoting airflow.[b] These interventions help cool urban areas, reduce energy consumption for air conditioning, and promote mental and physical health through access to nature.

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[a] Prolonged heat exposure can lead to heat stress, cardiovascular diseases, and even death.

[b] For example, Colombo in Sri Lanka has implemented vertical greening systems on walls to reduce heat as well as control air and noise quality. See: Rasindu Galagoda et al., "The impact of urban green infrastructure as a sustainable approach towards tropical micro-climatic changes and human thermal comfort," *Urban Forestry & Urban Greening* 34 (2018):1

Air Quality Improvements

Urban vegetation[c] also improves air quality by absorbing pollutants like nitrogen dioxide and particulate matter,[14] serving as natural air filters that enhance respiratory health and reduce the incidence of asthma and other chronic conditions exacerbated by poor air quality. However, careful planning of vegetation types and location of green infrastructure is essential to maximise health benefits, particularly in dense, heavily polluted areas.[d,15,16]

Flood Control and Water Management

As climate change leads to more extreme rainfall, cities face increased flooding risks that can cause waterborne diseases, disruptions in services, and economic losses.[17] Green infrastructure mitigates flooding by absorbing and managing stormwater through natural sponges,[e] which slow water runoff and reduce the burden on traditional drainage systems.[f,18] These approaches reduce the risks of waterborne diseases by minimising drinking water contamination and protecting critical infrastructure, ensuring health services remain operational during extreme weather events.

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c In both public spaces (parks, flower beds, trees), and private spaces (hedges, fruit trees).

d An exemplary case is in Medellín, Colombia, where the city's Green Corridors initiative integrates shading trees and green walls to reduce urban temperatures, enhance air quality, and improve living conditions for vulnerable communities. See: https://www.bbc.com/future/article/20230922-how-medellin-is-beating-the-heat-with-green-corridors

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Sustainable Housing: A Climate-Resilient Approach

Housing is another critical factor for urban resilience, as poorly designed, energy-inefficient housing can amplify climate risks, particularly for low-income communities.[19] In many cities, informal settlements are disproportionately affected by heatwaves, floods, and vector-borne diseases.[20] Therefore, sustainable housing designs that incorporate climate-adaptive features are essential for building resilient communities.

Energy Efficiency and Passive Cooling

Energy-efficient housing reduces reliance on fossil fuels, lowers greenhouse gas emissions, and provides cost savings to residents. In warm climates, passive cooling techniques such as reflective roofs, cross-ventilation, and high thermal mass material can lower indoor temperatures without the need for energy-intensive air conditioning.[21] This also reduces energy demand and prevents heat-related illnesses during heatwaves.[g]

Resilient Materials and Designs

As cities grapple with increasingly frequent extreme weather events, resilient construction materials and designs can reduce housing vulnerability to climate impacts.[22] Flood-resistant building materials and elevated designs protect homes from flooding in coastal and low-lying areas. In flood-prone regions of Bangladesh, for instance, floating homes have been developed to adapt to rising water levels,[23] showcasing the role of innovative design in building resilience.

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Building codes and regulations must be adapted to mandate climate resilience in housing projects, particularly in areas vulnerable to climate risks. This requires collaboration between urban planners, architects, governments, and communities to ensure housing projects are designed with the future climate in mind.

Climate-Adaptive Public Health Systems

A resilient city needs climate-adaptive infrastructure alongside robust public health systems to tackle emerging climate-related health threats.[24] As climate change intensifies, cities must strengthen their public health capacity to address new challenges, such as the spread of vector-borne diseases and heat-related illnesses, and the mental health impacts of climate change.

Surveillance and Early Warning Systems

Cities must implement real-time monitoring and early warning systems[h] for climate-related health risks. Surveillance systems can track environmental changes, such as temperature, humidity, and rainfall patterns, and predict diseases outbreaks like malaria, dengue, and cholera.[25,26,27] Public health authorities can then deploy targeted interventions, such as vector control, vaccination campaigns, or public health advisories, to minimise the health impacts. By integrating climate and health data, these systems enable proactive responses that reduce disease transmission and improve public health outcomes.

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Health Infrastructure and Climate Resilience

Health infrastructure must be resilient to climate impacts, ensuring that hospitals and clinics remain operational during emergencies.[28] Backup power systems, flood protection measures, and climate-adaptive building designs are essential to remain operational when they are needed.[1] These adaptations safeguard health services during crises and reduce the risk of health system failures.

Community Engagement and Capacity Building

Building climate resilience in public health systems requires active community engagement. Public health campaigns that raise awareness of climate-related health risks, such as extreme heat, poor air quality, or contaminated water, empower residents to take preventive measures. Training local health workers to recognise and respond to these issues can improve community resilience.[j,29] Engaging citizens in climate and health initiatives fosters ownership and strengthens local capacity to respond to climate challenges.

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Conclusion

Building cities resilient to the health impacts of climate change requires a holistic approach that integrates green infrastructure, sustainable housing, and climate-adaptive public health systems. Collaboration among urban planners, policymakers, and public health officials is essential to embed climate resilience in every aspect of city design and governance, optimising local solutions.[30] Green infrastructure provides natural solutions for cooling cities, improving air quality, and managing stormwater, while sustainable housing protects residents from extreme weather and heat. At the same time, robust public health systems are essential for responding to emerging climate-related health threats.

By embracing these strategies, cities can mitigate the health risks associated with climate change and foster healthier, more liveable urban environments for all residents. As the global climate crisis intensifies, the importance of resilient cities cannot be overstated.

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A Multilevel Governance Roadmap for Climate-Health Resilience in the Cities

Vikrom Mathur and Aparna Roy

THE INTERCONNECTED CHALLENGES of cities, climate change, and human health demand urgent attention, particularly in the Global South. Rapid urbanisation, socio-economic inequalities, and inadequate infrastructure increase urban vulnerability to climate impacts, positioning cities on the front lines of risk.[1] Addressing these interconnected issues requires a multilevel governance approach that involves coordination across global, national, city, and community levels to ensure that policies and actions favour the most vulnerable.[2] This article outlines how a multi-tiered governance framework can respond to these challenges effectively, focusing on policies and actions that prioritise the needs of vulnerable communities.

Global Governance and International Efforts

At the global level, multilateral organisations such as the United Nations (UN), the World Health Organization (WHO), and intergovernmental panels like the Intergovernmental Panel on Climate Change (IPCC) play essential roles in setting norms, developing frameworks, and facilitating international cooperation.[3] Global governance mechanisms need to prioritise the following:

- **Integration of health in climate agreements:** Historically, climate agreements have emphasised emissions reductions and energy transition without adequately addressing health. Global frameworks such as the Paris Agreement should include comprehensive health action plans that prioritise urban health impacts. This could involve integrating WHO's health guidelines into climate policy frameworks and ensuring that health metrics are included in measuring climate adaptation and mitigation outcomes.[4]

- **Support for climate-resilience financing:** Vulnerable cities in the Global South often face a shortage of financial resources to implement climate and health interventions. Initiatives such as the Green Climate Fund (GCF) and international financial institutions should prioritise financing for health-centric climate adaptation programmes, focusing on urban areas with high exposure to climate risks.[5]

  Establishing global financial mechanisms tailored to support multilevel urban interventions can enhance cities' capacities to protect human health by framing resilience as an investment in urban assets and systems.[6] Additionally, shaping international funding to fit local adaptation needs is essential to address the unique challenges of urban climate adaptation financing in resource-limited settings.[7]

- **Knowledge exchange and capacity-building:** Platforms such as the Global Covenant of Mayors for Climate & Energy facilitate city-level participation in global dialogues and promote the exchange of best practices.[8] This knowledge-sharing infrastructure should be enhanced to incorporate lessons on health and climate synergies, providing cities in the Global South with the tools to implement effective solutions.[9] Standardised data can further enable cities to achieve global climate goals, adapting strategies to local contexts in developing regions.[10]

National-Level Policy and Institutional Frameworks

National governments in the Global South play a pivotal role in scaling up and coordinating climate and health action. The creation of robust policy frameworks that include health objectives in national climate plans is essential for systemic change.[11] The following paragraphs outline the key strategies at the national level:

- **Integrated policy development:** National Adaptation Plans (NAPs) and Nationally Determined Contributions (NDCs) should incorporate health as a core element. Governments should develop inter-ministerial task forces that integrate climate action and public health strategies, ensuring that health systems are climate resilient and equipped to address both the direct and indirect health impacts of climate change, such as heatwaves, vector-borne diseases, and air pollution.[12] For effective implementation, national plans must integrate public health measures, monitoring, and data sharing between health and climate sectors to support timely responses,[13] with health-sector leadership playing a crucial role in framing climate change as a health issue and promoting systemic adaptation across sectors.[14]

- **Legal and regulatory mechanisms:** Establishing strong environmental health regulations, such as stringent air quality standards and urban heat management policies, can drive city-level action. National governments can implement regulations that will incentivise cities to adopt green infrastructure, energy-efficient public transport, and sustainable urban planning.[15]

- **Funding and technical support:** National governments need to allocate funds and provide technical assistance to municipalities for implementing climate-health initiatives. This could include subsidies for community-based projects, grants for public health research in urban environments, and partnerships with academic and non-profit sectors to foster evidence-based policymaking.[16]

City-Level Implementation and Policy Innovation

Cities are at the forefront of climate change and health impacts, making city-level action essential.[17] Urban governments should act as primary implementers of global and national policies while innovating context-specific solutions. Strategies for city-level action include:

- **Urban planning and resilient infrastructure:** Cities need to prioritise sustainable urban design that mitigates the effects of climate change and improves public health. This involves creating green spaces that reduce heat islands, implementing flood control measures, and upgrading slum infrastructure.[18] For example, cities can model after projects such as the Green Corridor initiative in Medellín, Colombia, which reduced temperatures and improved air quality in the city.[19]

- **Integrated multisectoral governance:** Targeted, sector-specific health governance approaches are crucial to address vulnerabilities linked to urbanisation and climate risks in cities of the Global South.[20] While comprehensive cross-sectoral integration is ideal, practical applications are often more focused. For instance, urban health adaptation efforts in Indian cities have concentrated on specific sectors, such as waste management in Surat and transportation in Delhi.[21] Expanding this approach to incorporate other sectors, such as water management, housing, and energy, could further enhance climate resilience and address diverse urban health challenges.

- **Data-driven decision making:** Municipal governments must leverage data to effectively understand and address local health and climate challenges. Alongside environmental data on air quality, heat levels, and other climate variables,[22] collecting and using health data is crucial. By linking climate and health data, cities can better understand the health impacts of climate stressors and design targeted interventions. However, data collection is often inadequate, especially in informal settlements where health risks are high. A centralised data repository that combines climate and health information, with contributions from both public and private sectors, would greatly improve resource allocation and planning. Strengthening data systems can pave the way for more effective urban-resilience strategies.

- **Inclusive governance and participatory approaches:** Engaging with community leaders, civil society, and marginalised populations ensures that policies reflect the needs and knowledge of those most affected. Participatory planning processes enable the co-creation of solutions that are culturally and socially tailored, increasing their effectiveness and sustainability.[23]

Community-Level Engagement and Grassroots Action

The community is where the most significant impacts of climate change and health intersect, and local knowledge and actions can yield impactful results, empowering communities to lead adaptive measures that foster resilience and engagement. Key aspects include:

- **Building local capacity:** Community health workers and local organisations can be trained in climate and health resilience strategies. Such training can include educating residents on subjects such as the prevention of heat strokes, vector control for mosquito-borne diseases, and emergency response during extreme weather events.[25]

- **Locally led development:** Solutions developed at the community level are often more sustainable and culturally relevant. Community-based organisations (CBOs) should be supported to initiate local projects that increase climate and health resilience. Funding mechanisms that prioritise small grants for community-led initiatives can enable grassroots action to scale effectively.[26]

- **Social equity and inclusivity:** Addressing health and climate issues in urban areas requires focusing on the most vulnerable groups, including the elderly, children, and the poor. This can be facilitated by city programmes that specifically target low-income neighbourhoods, such as for upgrades in housing and infrastructure resilience.[27]

Towards a Multilevel Governance Framework

Working within the complex intersection of cities, climate change, and human health requires a coordinated approach that leverages the strengths of all governance levels. Global

frameworks provide overarching guidance and resources; national policies align broader goals with sectoral actions; city-level governance translates these policies into practical, localised action; and community-level engagement ensures that solutions are equitable and grounded in local realities.

The Global South, with its unique set of challenges, must be at the forefront of these efforts. By adopting multilevel governance frameworks that prioritise collaboration, inclusivity, and targeted interventions, urban areas can transform their approach to climate change and human health. Ultimately, this pathway not only supports immediate adaptation needs but also promotes sustainable urban development that centres on the well-being of the most vulnerable populations.

This comprehensive, integrated framework ensures that cities can remain resilient, habitable, and inclusive in the face of growing climate challenges, creating a more equitable future for all.

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