



Evidence review: Extreme heat in informal settlements

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Executive summary

Extreme heat is a critical issue for global resilience.. The impacts of extreme heat are not uniform, with concentrated and intersecting risks in cities of particular concern. Climate risk frameworks interpret climate risk as a function of climate hazards, exposure, and vulnerability. Cities experience hotter temperatures due to the urban heat island effect, where buildings, concrete, density and infrastructure trap heat. Cities hold most of the world's population and are characterised by socio-economic and spatial inequalities, making them sites of dense and but often unequal exposure. People living in informal settlements – 1.1 billion people globally – are disproportionately vulnerable, given their lack of access to adequate housing, infrastructure and services.

This paper considers the primary issues of planning, finance, and delivery of responses to extreme heat in informal settlements. And it explores the associated entry points for action and research that emerge as a result. The authors identified entry points in relation to urban planning, namely: disaggregated local data and evidence for planning; improved and integrated approaches to spatial planning that incorporate climate risks and development priorities; and the mainstreaming of participatory and co-produced planning for sustainability and equity. They identified two entry points related to finance, namely decentralising climate finance and innovative financial instruments. The authors identified four entry points in relation to the delivery of support and strengthened implementation of climate-resilient development, namely: enabling community-led and co-produced delivery mechanisms; strengthening collaborative governance; improving integrated structures within government; and working with networked organisations and approaches. Integrated, participatory action and research across each of these entry points will help to ensure climate resilient development for those living in informal settlements in the face of extreme heat risks.

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Understanding extreme heat in cities

Extreme heat is a critical issue in global resilience discussions [1], reflected in the United Nations' recent call for a comprehensive global strategy to manage and mitigate its effects [2]. The increasing frequency of extreme heat is one of the most direct and dangerous manifestations of climate change, posing significant threats to human health, productivity, and the built environment. Temperatures over 40°C and even 50°C are becoming more common in many regions [3] with extreme heat responsible for most weather-related deaths worldwide. By 2100, between 50% to 75% of the global population could be exposed to life-threatening heat and humidity [4].

Cities, which are home to 55% of the global population [5], have seen a near 200% increase in extreme heat exposure between 1983 and 2016 [6]. Urban heat exposure is amplified by the urban heat island effect, where urban structures absorb and retain heat, raising temperatures by as much as 10–15°C relative to surrounding rural areas [7]. The resulting elevated temperatures exacerbate heat stress and increase the risk of heat-related mortality in cities [8]. Many cities will become places where extreme temperatures persist for nearly half the year [9]; heat is increasingly recognised as a critical urban challenge. Focusing on cities allows for targeted interventions that address both the immediate risks of heatwaves and the broader systemic issues exacerbated by unplanned and informal urbanisation.

i) Heat and informal settlements

The effects of extreme heat are disproportionately felt by low-income urban communities, particularly those living in informal settlements. Globally, around 1.1 billion people reside in informal urban areas—slums or settlements without adequate infrastructure or services [10]. These settlements are often located in areas most affected by extreme heat, and they lack basic service infrastructure like water, electricity,

and sanitation, which could help mitigate the dangers of high temperatures. Given the scale and longevity of many informal settlements, they should be regarded as a permanent feature of city landscapes and included in climate and urban upgrading [5], [11].

The urban heat island effect is exacerbated in informal settlements due to poor building materials and lack of green spaces [12], [13]. Buildings are typically made of materials that absorb heat, and the lack of proper insulation leads to higher indoor temperatures. Most residents do not have access to or cannot afford utilities (electricity, water) to help keep them cool and avoid becoming dehydrated [14]. In addition, many residents of informal settlements rely on livelihoods that enhance their exposure to high temperatures [15]. As a result, the residents of informal settlements typically experience chronic heat stress conditions [16], [17], [18].

The unplanned and often dense growth of informal settlements also limits access to healthcare and emergency services, further increasing the vulnerability of residents to extreme heat events. While planned urban densification can offer benefits such as reducing transportation emissions and improving service access, these advantages are not realised in informal settlements, where unplanned expansion leads to increased vulnerability.

Addressing extreme heat requires us to focus on reducing temperatures and consider interconnected climate risks. Poor air quality, water scarcity, and energy poverty often coexist with extreme heat, creating compound risks for residents of informal settlements [19]. Tackling heat in urban areas provides an entry point to address these multiple vulnerabilities and to deliver broader social and economic benefits, such as improving housing, increasing access to services, and promoting environmental sustainability.

ii) Socio-economic and health implications

The economic implications of climate change are significant for cities in developing nations [20]. Cities account for around 80% of global economic output, and the economies of many developing countries are concentrated in urban areas [21]. Climate change is expected to severely impact these economies, particularly informal economies, which provide around 60% of employment in developing nations [22]. If climate risks go unaddressed, up to 130 million people could be pushed into poverty over the next decade [23].

Climate change also threatens global food and water supplies. Droughts, extreme heat, and changes in rainfall patterns are already affecting agricultural production, leading to long-term consequences for food security and increasing rural-to-urban migration [24]. By 2050, climate change could increase the amount of time women in households without running water spend collecting water by up to 30% [25]. Changing weather conditions also contribute to an increased spread of disease, with climate change increasing the impact of more than half of all known human pathogens [26]. In an urban context, issues of poverty and density of settlements are shown to impact the transmission of diseases within population groups. These climate-related disruptions, along with declining air quality, pose serious health risks to urban populations [27]. Prolonged warm seasons and pollution exacerbate respiratory and cardiovascular diseases [28], with air pollution causing around seven million premature deaths annually [29] and costing the global economy \$8.1 trillion a year [30].

iii) The importance of tenure security

Securing tenure—ensuring the right to remain in one's home without the threat of eviction—is critical to building resilience in informal settlements [31], [32], [33], [34]. Tenure security is often complex in these areas, with competing claims to land ownership and little formal legal recognition. In countries like Brazil and India, residents

can sometimes gain de facto tenure security through legal recognition of housing rights or public investment in upgrading settlements [35], [36]. Secure tenure allows residents to invest in improving their homes and services, reducing vulnerability and increasing resilience to climate risks including heat. A global model of large-scale housing improvements in informal settlements shows that secure tenure can lead to significant economic, health, and social benefits. For example, equitable access to adequate housing could boost GDP per capita by up to 10.5%, increase life expectancy by 2.4 years, and reduce preventable deaths by over 738,000 annually. Additionally, improved housing and economic conditions could lead to 41 million more children attending school [37].

iv) The opportunity

Extreme heat, layered with other climate risks, poses severe challenges to urban populations, particularly those living in informal settlements. As cities continue to grow and climate change worsens, these risks will intensify unless action is taken. Addressing these issues requires a coordinated, multi-tiered approach that integrates social justice and equity, focuses on vulnerable populations, and improves resilience in the face of climate challenges.

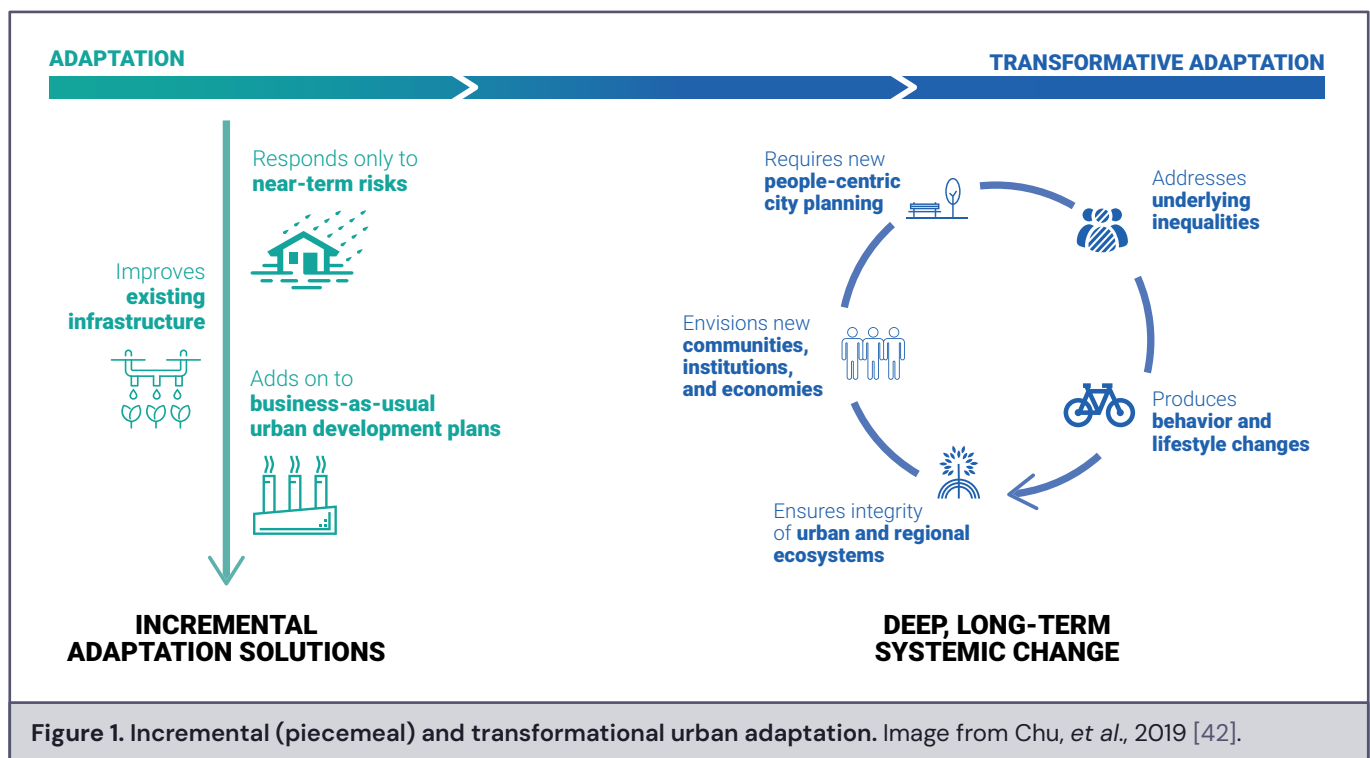
This paper demonstrates why informal settlements are critical hotspots for climate action and considers how governments and urban planners can develop more sustainable and equitable urban environments. By adopting more inclusive governance and decision-making structures, alongside targeted investments in tenure, infrastructure, housing, and services, cities can work with vulnerable populations to build resilience in the context of growing climate change risks.

Cities as key sites for climate resilient development

Climate resilient development addresses climate change from the perspective of development. This approach seeks low-carbon development pathways that are equitable and significantly increase adaptive capacity. This therefore decreases the harmful effects of climate change which are disproportionately experienced by poor, vulnerable and disenfranchised populations [38]. Climate resilient development responds to the risks of siloed climate and development priorities and artificial divisions between mitigation and adaptation strategies. These are: missed socio-economic opportunities, widening inequalities and vulnerability gaps between the poor and the rich, and maladaptation resulting in long-term instability.

The concentration of people, power and resources make cities key sites of innovation and transformative change. However, in most cities, the dominant framing of climate risk management is often focused on siloed problem-solving, addressing immediate challenges without

a wider consideration of the integration of the physical and socio-economic factors needed for transformational adaptation [39]. This piecemeal approach can lead to fragmented cities, with displaced rather than resolved risks, reinforcing social inequalities [40]. For example, urban greening policies that gentrify low-cost areas of cities can further fuel socio-economic alienation [41]. They exclude the poorest from shelter near economic centres or they bring about the privatisation of water services which result in unaffordable pricing. There needs to be a shift towards transformational urban adaptation practices that drive sustained change and safeguard the interests of the most vulnerable citizens. This means developing systemic changes to development processes that make cities more socially and economically vibrant and which ensure resilient and inclusive urban settlements [42]. Whilst dominant (i.e., reactive and piecemeal) adaptation approaches tend to be depoliticised and technocratic in nature, transformational approaches seek to address the systems and root causes that produce vulnerability [42].



Transformative adaptation approaches require multi-level actions that value collaborative governance. Transformative adaptation cannot be top-down or bottom-up, but needs the engagement of national and regional agencies, city planning departments, and private actors – including communities themselves – to improve the physical resilience of urban infrastructure and systems.

Civil society organisations and households can implement cost-effective small-scale projects which directly respond to specific hazards and can quickly benefit residents' livelihoods [43].

Low-income urban residents have also been able to collectively negotiate with local governments to deliver risk-reducing services and infrastructure at larger scales. The ACCA (Case Study 1) case study demonstrates how a community-led approach enabled by decentralised finance can trigger wider investment into urban adaptation.

Case Study 1: Asian Coalition for Community Action (ACCA) – launched by the Asian Coalition for Housing Rights in 2008. ACCA provided small grants to communities that are matched by local savings to undertake housing and environmental adaptations. Grants were intentionally small, and ACCA encouraged communities to use their own resources to co-deliver key improvements. Investment included road building, sewers and drainage, community toilets, electricity supply and housing upgrading. The activities incentivised local governments to invest in connecting infrastructure or addressing tenure issues, thereby scaling the impact. ACCA was implemented in 1,000 settlements in 165 cities and 19 Asian countries, strategically releasing the capacity of communities to lead development and climate adaptation works [44].

Despite many urban communities and civil society organisations being well organised with a high capability to engage with planning processes, these residents are often excluded from formal decision-making. Their pathway of participation and influence can be limited by government processes and capabilities, or the failure of local authorities to see vulnerable populations as stakeholders and partners [45]. Across appropriate time periods, multi-scalar governance interventions are required. Adaptation efforts can put cities on stronger, safer trajectories where synergies across climate adaptation and mitigation work are realised and where persistent problems – like inequality and basic infrastructure deficits – are tackled.

The response of cities to changing climate conditions is, in many instances, limited by the informational (data at a useful scale), financial (resources commensurate to need), and institutional (policy, legal and cultural) capacity of governments and other urban stakeholders. The complex and politicised character of cities can be an obstacle to communication between communities and local government, particularly on the upgrading of settlements that lack formal status. **This paper now considers the primary issues of planning, finance, and delivery, and explores the associated bottlenecks and research agenda that emerge as a result.**

Planning for climate resilient development in cities

There are three specific bottlenecks identified in relation to urban planning, namely:

- a lack of disaggregated local data and evidence for planning;
- the need for improved and integrated approaches to spatial planning that incorporate climate risks and development priorities;
- and the mainstreaming of participatory and co-produced planning for sustainability and equity.

Each bottleneck provides a useful entry point to tackle climate risks in informal and vulnerable urban settlements:

i) Disaggregated data for evidence-based planning

Accurate and disaggregated data on climate impacts, housing conditions, infrastructure, and service deficit as well as socio-economic data is essential for evidence-based planning [46]. This data enables planners and policymakers to understand the specific vulnerabilities and needs of different communities, facilitating targeted and effective adaptation strategies. **Gaps in accurate local data on climate risks and unmet needs are exaggerated in cities, where the complexity of urban systems, informality, a lack of active engagement of low-income community members and fragmented governance arrangements make joined-up responses to climate risks more difficult.** Despite informal settlements constituting a large portion of urban populations, they are often absent from official records [47]. While networks such as Slum Dwellers International (SDI) have been effective in enumerating settlements and using this information to inform upgrading and partnership action, [48] inconsistent use of

participatory survey methods and a lack of focus on providing scientific data at a settlement level are significant barriers to understanding climate impacts and planning for change.

There is a significant gap in data on the impact of heat on urban environments and the health of citizens.

Figure 2, overleaf, shows that the expansion of Dar es Salaam between 2003 and 2022 corresponds with changing heat patterns, with rising day and nighttime temperatures in core and low-income settlements of the city. While there is an expanding body of data on heat and heat islands, there is largely an absence of data on informal settlements [19]. There are examples of participatory heat data collection underway (for example in Argentina and Tanzania),¹ where community-led research is being used to capture information on impact and coping strategies at a settlement and household level to inform intervention design. These models, where standardised and supported by networks, such as SDI, create frameworks that could be shared and extended across cities. Heat data could more effectively be deployed to inform policy, in particular spatial planning, in order to integrate adaptation and mitigation measures into urban design. The loss of the natural environment in the form of green space, tree cover and permeable surfaces, the density of urban development that traps heat in settlements and choices of building materials and design that are thermally inefficient, are all issues that could be addressed in policy. That could lead to more considered use of and communication of climate data, particularly within vulnerable urban communities [49].

¹ IIED supported projects in Buenos Aires, funded by IKI and Dar es Salaam, funded by the World Bank.

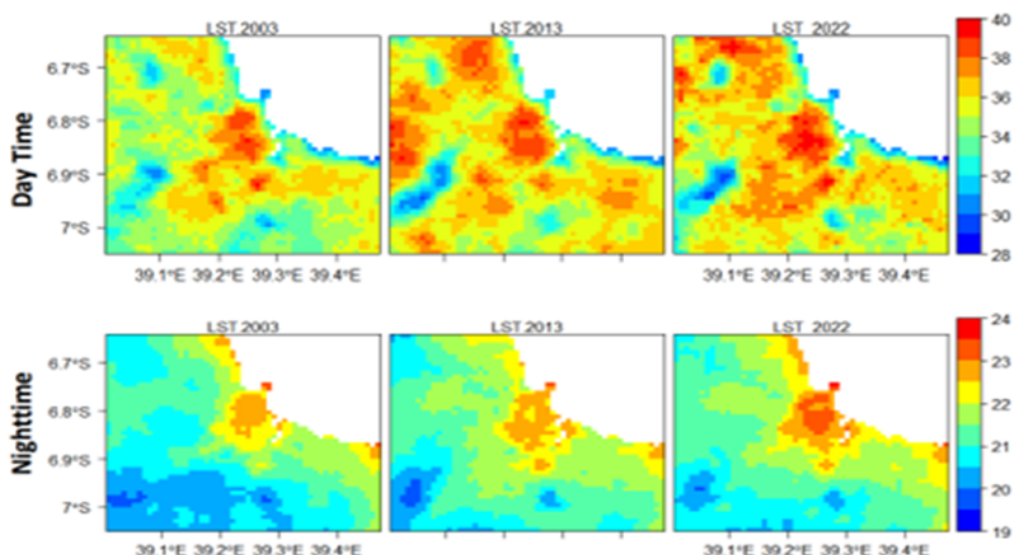


Figure 2. Changing heat patterns in Dar es Salaam. Image from Morakinyo, *et al.*, 2024 [50].

Case Study 2: Tanzania’s Federation for the Urban Poor has been collecting data to better understand the impacts of climate change, particularly extreme heat, on low-income urban communities, and have been using this knowledge to inform the design of more effective adaptation. The project considers conditions that mediate climate risks (e.g., housing construction materials and design), perceptions of climate risks, the impact of rising temperatures and possible responses. The project is supported by the Centre for Community Initiatives (CCI), with funding from the World Bank.

ii) Improving the effectiveness of spatial planning for development and adaptation in cities

There are several, often regionally focused, urban networks working to support cities to be more responsive to climate risk. Among others, the Resilient Cities Network [51], the Cities Climate Finance Leadership Alliance [52] and Cities Race to Resilience [53] are building the capability of cities to address climate issues. However, these types of initiatives are often limited in coverage and reliant on formulaic tools, rather than a more embedded building of capacity.

Cities face a significant challenge in creating the capacity to meet continued growth, without adding to sprawl or further diminishing natural environments. Even where there is action to reinstate natural protections (in coastal and estuarine cities) or investment in ‘risk reducing infrastructure’ (such as drainage

or electricity networks), the scale, coverage and inclusion of informal areas is much lower than needed to reduce climate risks [43]. Often state and donor programmes fail to connect initiatives together at a local level, creating ‘islands’ of improvement within cities. Poor coordination between government departments or a lack of scope in donor programme design prevents the exploitation of major investment (i.e., trunk drainage systems) by organised communities to extend into informal settlements.

Effective planning should seek to integrate informal settlements into the broader urban fabric, addressing issues of spatial segregation and ensuring that these areas are connected to essential services and infrastructure. This includes the preservation and enhancement of natural environments, such as green spaces and water bodies, which can mitigate climate risks and improve the overall liveability of these areas.

Case Study 3: In 2017, residents of Mukuru settlement undertook an ambitious participatory upgrading process known as the Mukuru Special Planning Area (SPA). In addition to activities to improve resilience, [54] this process has promoted spatial integration of the informal settlement into Nairobi's planning processes, including by working closely with the County City government on locally-appropriate planning [55]. Since the declaration of the SPA, there has been a significant improvement in the recognition of the informal settlements and their efforts for integration with the wider city [56].

iii) Mainstreaming participatory planning:

Business-as-usual city planning is built on predictive and probable outcomes, whereas transformative change demands that city futures need to be values-driven. Participatory planning approaches promote processes that translate the needs and ambitions of citizens, in particular low-income communities, into new visions and imaginations of how a city could be [57]. Such an approach helps to ensure that a city's specific social and economic contexts (including poverty, population health, informal economic activity, or access to water and sanitation) frame the planning process and that local equity and justice issues are at the centre of programme design.

The complex and politicised character of cities can be an obstacle to communication between communities and local government, particularly on the upgrading of settlements that lack formal status. Involving residents of informal settlements in the planning process is critical to ensuring that adaptation measures are contextually relevant and address the specific vulnerabilities of these communities [58]. Participatory planning can lead to the identification of local risks, such as heat islands or flooding, and can help prioritise the interventions that are most needed.

Case Study 4: Heat-resilient Action Plans Heat-resilient action plans for cities or settlements focus on mitigating the impacts of extreme heat by integrating climate-responsive urban design, enhancing green infrastructure, and improving community preparedness. These plans aim to protect vulnerable populations, reduce heat-related health risks, and ensure that cities can adapt sustainably to rising temperatures. The most effective examples adopt a participatory approach. For example:

- Freetown (Sierra Leone) is developing a Heat Action Plan (under the City's Climate Action Strategy [59]) that aims to have 80% of the city's population fully aware of heat-related risks and effective responses by 2030, supported by heat early warning systems, heat-sensitive infrastructure and cooling corridors. This will be informed by a participatory city-wide heat mapping exercise. In addition, the plan aims to implement suitable measures targeting at least 50% of the informal settlements to improve their ability to adapt to extreme heat by 2030.
- Ahmedabad (India) has developed a Heat Action Plan [60] together with an early warning system that issues warnings seven days before a heatwave, allowing city officials to plan their response. The Plan considers informal settlements in its advocacy and shelter provision and involves slum leaders in planning. Following their lead, several other Indian cities (including Delhi) have followed suit.

iv) Data and action research gaps for planning

● Disaggregated data and local knowledge for local evidence-based planning

- More disaggregated data is needed on inter-connected climate risks such as heat in vulnerable communities that can support local processes and aggregated to understand city/national/regional trends. For example, understanding how extreme heat is experienced within settlements and across cities by different groups.
- There is an opportunity to synthesise local knowledge and scientific knowledge on climate risks and responses in informal settlements.
- An enhanced understanding of local government and community capacity for co-produced data collection on climate risks and unmet needs could support implementation work and enable capacity building where it is needed.

● Improving integrated spatial and climate planning

- What climate risks and challenges are faced by residents of low-income and informal settlements – and how are they linked? And how can this inform integrated solutions for both? What is the role of tenure security in terms of climate resilience? What implications does this have for planning, finance and implementation?

● Mainstreaming participatory planning

- What governance and decision-making arrangements can best enable equitable participation of all stakeholders including marginalised communities?
- How can nature-based solutions respond to development challenges in informal settlements as well as responding to extreme heat?
- Improved understanding of local needs and the social and economic implications of certain climate responses to avoid funding maladaptation and inequitable outcomes within settlements and cities.

Financing climate resilient development in cities

Although adaptation finance grew modestly in 2021/2022, reaching USD 63 billion, the global adaptation funding gap is widening.

Tracked adaptation finance remains dominated by public actors (98%), national and multilateral Development Finance Institutes (DFIs) providing predominantly market-rate debt for adaptation and concessional lending, and governments providing grant financing for adaptation.³ Collectively DFIs and governments financed 61.5 billion of the 63 billion USD on adaptation in 2021/22. Philanthropic grants for adaptation accounted for only 0.49 billion USD over 2021/22.

An overlooked source of adaptation finance that is in addition to national governments and DFIs is the financial contribution of individual households.⁴ Evidence from Bangladesh suggests that households (notably women) are likely to be the largest source of finance for climate and disaster risk reduction investments.⁵ Research from sub-Saharan Africa suggests that 30% of informal settlement household income is spent on housing repairs including household risk reduction [37]. Considering 60% of people in sub-Saharan Africa live in informal settlements, this is a significant proportion of total household spending.

Financing climate-resilient infrastructure in cities requires strong fiscal foundations, reliable revenue sources, and robust financial management at the local level. While the climate crisis adds urgency, it does not change the essential need for solid municipal financial planning and systems to support action.

There are two useful entry points to tackling climate risks in informal and vulnerable urban settlements identified, namely **decentralising climate finance** and **innovative financial instruments**:

i) Decentralising climate finance

With a majority of global climate and development funding flowing to national governments, a lack of decentralisation can be a barrier to city level investment in adaptation. Limitations in national budgets, the level of political priority given to cities within national programmes and the capacity of different tiers of government to raise and manage funds [61] all determine the levels of resources available. Strong vertical relationships to and from national government on climate targets are essential to create effective structures for delivery [62], [63], but multi-level climate governance [37] is limited, with less than 10 per cent of climate finance finding its way to the local level [64].

³ Summary of the adaptation financial instrument landscape in 2021/22: market-rate debt amounted to USD 37.5 billion (60% of the total adaptation finance in 2021/2022), concessional lending (USD 13 billion, 21%), grants (USD 11 billion, 17%). Of the USD 1.5 billion tracked private adaptation finance in 2021/2022, 38% was debt from commercial financial institutions, followed by grants from philanthropies (30%), with the remainder funded as equity by corporations. The figures presented do not include funding tagged as “dual benefits” (delivering both mitigation and adaptation benefits) which also increased to USD 51 billion and was similarly financed by public sector institutions. Buchner *et al.* (2023) Global Landscape of Climate Finance. Climate Policy Initiative [65].

⁴ The Global Landscape of Climate Finance (Buchner *et al.*, 2023) [65] does not document spend from households/individuals on climate adaptation. Similarly the Climate Policy Initiative (2023) State and Trends in Climate Adaptation in 2023 report [66] does not make reference to household spending on adaptation.

⁵ Eskander, S and Steele, P (2019) Bearing the climate burden: how households in Bangladesh are spending too much. IIED, London [67]. Though the research focuses on rural households in Bangladesh, the findings that household adaptation finance is underexplored and difficult to track could be applied to urban settlement household adaptation finance.

Even where funds are locally directed, this does not guarantee local control of decision making [64]. Studies have identified gaps in institutional structures to enable the practical implementation of decentralisation that limit the functionality of integrated national to local structures [68]. Climate finance can usefully be deployed to support the institutionalisation of long-term collaborative climate governance, for example the urban labs discussed in section 5 on delivery, which can guard against short-term priorities and political change.

To ensure that adaptation finance reaches the local level, there must be a stronger focus on decentralising funds from national governments and international donors to city governments and local communities. This requires building the capacity of local authorities to manage and disburse funds effectively and transparently as demonstrated by an emerging initiative focused on driving climate action at the district level in Uganda [69]. Local communities are included in decisions on which adaptation interventions are funded.

The lack of an effective enabling environment to direct funding to the local level or to incubate and scale successful pilot schemes is a constraint on urban adaptation programmes delivery. This has been termed a 'missing middle' [64], that prevents the adoption and mainstreaming of innovation at a city and national scale. Investing in the 'missing middle' to build organisational strength at a local level and create the space to grow and embed successful pilot schemes on the 'frontline' is vital to realise the full value of local ideas at a city scale. Pilot projects on the frontline have a hard time scaling from community to city-level, funding the 'missing middle' can enable this scaling.

ii) Innovative financial instruments

Processes used to allocate adaptation finance, particularly global or bi-lateral funds, can overly rely on tight eligibility, management, performance and reporting criteria, or be slow to respond to need. This can be a major barrier that deters involvement of local governments and non-state groups in donor funded delivery and limits innovation [70]. Requirements for mature organisational systems or accounting procedures may conflict with more socially oriented collective action or may be unachievable without access to long-term core funding for local groups.

Firstly, the dominance of informal economic activity and weak tax raising powers in Global South cities is often a major constraint on the ability of local governments to generate the revenue to support infrastructure, service improvements and climate adaptations [71]. Cities can explore the use of innovative financial instruments, such as green bonds and city resilience bonds [72] or local climate adaptation funds, tailored to the needs of informal settlements. These tools can help attract private investment and provide a more stable source of adaptation funding.

In the case of Ghana, for example, systematic under-collection of income tax, VAT and corporation tax limits investment options, with estimates that only half of the country's eight million taxpayers actually pay tax [73]. Similarly, there is little use of development levies, in cities where there is a strong commercial market for business and residential construction, to subsidise the infrastructure costs for lower income population groups. Some cities can use new financial products, such as municipal and resilience bonds [46] to supplement domestic revenue, although these tools are difficult to access where cities lack the legal authority, credit rating or technical capacity to employ financial instruments. In these instances, finance needs to be used strategically to reduce pressure for informal settlement and target climate adaptation to areas of greatest vulnerability [43].

Case Study 5: In 2017, the City of Cape Town issued South Africa's first green bond to fund and refinance projects to address water supply shortages [74]. Accredited by the Climate Bonds Initiative and raising ZAR 1 billion (~USD 59 million), the bond improved water management and conservation, as well as delivery. A similar approach could be used to enhance resilience in informal settlements. For example, green bonds could be used to fund cooling infrastructure, water management and upgrading housing. Cost savings or revenue generation could be used to service the bond e.g., improved water management might reduce the cost of emergency services or response, freeing up city funds for interest payments.

Secondly, organised communities including federations of the urban poor have experience of organising and using their collective savings or funds from philanthropy to initiate upgrading and adaptation initiatives and take them to scale. Groups such as the Asian Coalition for Housing Rights (ACHR) (Case Study 1 describes the ACHR community action programme ACCA funded by City Development Funds) and SDI have used savings to formalise housing, install water and sanitation improvements and contribute to road and drainage works in the absence of local government leadership [75]. Community investments are often limited to small-scale incremental works, but when boosted by philanthropy or match-funded by government, more substantial progress is possible through co-production.

Thirdly, there are emerging examples of more nimble forms of finance that can respond to the impacts of climate change. Parametric insurance schemes have demonstrated potential to enhance resilience in vulnerable settlements and cities [76]. In Nairobi, the general approach to disaster risk management has relied heavily on post-disaster humanitarian aid, which can be reactive and inefficient. By adopting a parametric insurance model like ARC (African Risk Capacity), Nairobi could have a pre-arranged financial safety net that triggers payouts based on pre-defined weather events. This would ensure that resources are available immediately, reducing the response time and mitigating the overall impact of the disaster.

Case Study 6: Savings provide a platform for urban residents to mobilise around secure land tenure and basic services [77]. These mechanisms can be scaled up via group networks. For example, saving groups can form federations to create urban poor funds at city and national levels, as seen within the network of Slum Dwellers International (SDI). For example, the Zimbabwe Homeless People's Federation (ZHPF) collect savings through the Gungano Urban Poor Fund, which was used to finance a scalable community-led housing project that enhanced resilience, including to extreme heat through improved construction materials and planting trees for shade, for example. Community funds were used to leverage additional investments; for example, the City of Harare has co-financed the upgrading fund [43].

iii) Data and action research gaps for finance

● Decentralising climate finance

- What proportion of climate finance currently reaches cities and settlements in different regions?
- How much climate finance is currently available for resilient, integrated upgrading for vulnerable and informal settlements across cities?
- What are the barriers and constraints for decentralisation of finance?
- Do integrated climate actions that respond to mitigation and adaptation priorities offer better value for money?
- How can integrated climate finance catalyse positive change in by promoting more equitable local development outcomes?

● Innovative financial instruments

- What are the mechanisms and vehicles that can facilitate the decentralisation of finance to local communities, the private sector, and/or collaborate climate decision making institutions?
- How can we scale decentralised finance for pilot interventions to the city level?
- What are the equity and distributional implications of different finance mechanisms for vulnerable and low income urban communities?
- How can networked community savings be used to leverage and guarantee additional climate investments in informal settlements across cities?

Delivering climate resilient development in cities

There are four specific entry points identified in relation to urban delivery to support and strengthen the implementation of climate-resilient development, namely **enabling community-led and co-produced delivery mechanisms; strengthening collaborative governance; improving integrated structures within government; and working with networked organisations and approaches.**

i) Enabling community-led and co-produced delivery mechanisms

Community-led or co-produced delivery ensures contextual relevance, unlocks local knowledge and builds local capacity. Empowering communities to (co-)lead the delivery of adaptation measures can significantly enhance the relevance and effectiveness of interventions [78]. This approach draws on the local expertise and ingenuity of residents, particularly in informal settlements, enabling them to identify and implement solutions tailored to their specific needs and contexts. However, the climate discourse remains highly technocratic [79], [80], which can exclude community voices. Furthermore, many informal settlements lack established processes for participatory decision-making and public service provision

[81], which hinders the integration of community-led initiatives into broader adaptation strategies. Addressing these gaps is crucial to ensuring that community-based adaptation is not only effective but also genuinely inclusive, allowing for mutual learning, reinforcement, and capacity building in the delivery of climate-resilient development. In most cases, this requires reframing the decision-making context to empower communities [82].

ii) Strengthening collaborative governance

Collaborative governance between diverse stakeholders is necessary for coherent programming and city-wide responses [83] particularly given the diverse constellation of actors involved in designing, financing, implementing, monitoring, and sharing lessons from urban adaptation. A lack of coordination between stakeholders can result in gaps in, or weak penetration of, services, particularly in low-income communities. This inefficiency not only reinforces spatial disadvantage but also misses opportunities to leverage funding for a more comprehensive approach to city challenges. Existing governance structures rarely encourage meaningful participation from all stakeholders, particularly marginalised groups. To address

Case Study 7: The Dzivarasekwa Slum Upgrading Project, co-produced by the Zimbabwe Homeless Peoples Federation (ZHPF) and their support NGO Dialogue on Shelter Trust for the Homeless, and the City of Harare, exemplifies how community-led or co-produced delivery can ensure contextual relevance, build local capacity and reframe relations between informal settlement communities and local government. In this initiative, residents were deeply involved in every stage, from data collection to construction, ensuring that the solutions implemented—such as government-approved housing, solar-powered water systems and a connection to the energy grid—were tailored to their specific needs. By empowering the community to co-lead the project, the initiative not only improved living conditions and climate resilience but demonstrated the feasibility of delivering adequate housing and basic services in ways that are affordable and accessible to the poorest. This also helps to institutionalise a radically different government approach to informal settlements through the Harare Slum Upgrading Programme (HSUP). See also: Examples of Case Studies 2, 3 and 4.

Case Study 8: Urban Labs foster collaboration between different levels of government, urban communities and others to tackle complex urban challenges, grounded in the economic and political realities of cities. In doing so, they provide a means to enable joined-up investment at a local level, whilst generating evidence around necessary institutional, policy and legislative reforms, particularly in contexts where there is limited decentralisation of powers and resources to cities. For example, five urban labs were established in Latin American cities, including Buenos Aires (Argentina) [84] and Recife (Brazil), to pioneer inclusive climate action aligned with decarbonisation.

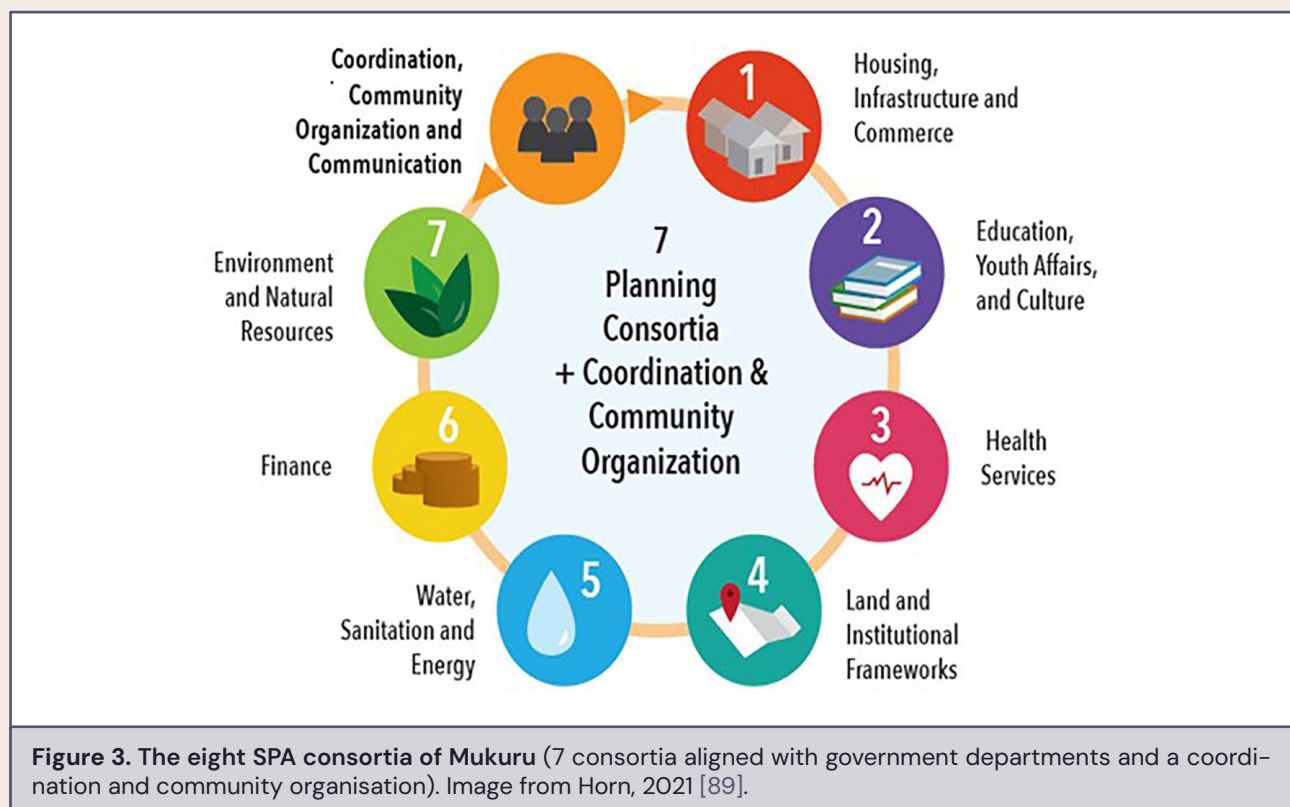
these gaps, **collaborative governance structures, such as urban labs or multi-stakeholder platforms, which leverage and build social networks, can facilitate more coordinated and integrated approaches to adaptation, ensuring that efforts are aligned and that resources are used efficiently** [85].

Closing the gaps for collaborative, delivery requires stronger processes i.e., ‘soft infrastructure’ in order to facilitate learning, integrated planning, and collaborative climate action between diverse stakeholders. An important demonstration of this is SDI’s use of exchange visits between urban poor Federation groups in different countries [86]. Taking groups of Federation members, local government officers and politicians to study familiar urban development problems in different country contexts has helped participants to not only see the challenges in their own cities in a different light, but also to see strengthened bonds between community and government that have had lasting benefits. Nurturing relationships can help to overcome entrenched perspectives and bias and create new spaces for collaboration. These are vital for soft infrastructure. However, it is difficult to realise improved soft infrastructure of cities, and the development and climate systems through government-funded initiatives alone.

iii) Improved integration within and between government agencies

Improved integration within and between government agencies is crucial for the effective delivery of climate-resilient development, particularly in urban settings. That’s because it ensures that policies, planning, and implementation processes are coherent and aligned across different sectors and thematic areas, such as climate mitigation and adaptation [87]. However, several gaps hinder the realisation of this integrated approach. The entrenched, siloed nature of government departments often results in fragmented efforts, leading to inefficiencies, conflicting priorities, and missed opportunities for holistic solutions. This is particularly true for urban climate challenges, which do not adhere to the boundaries of individual sectors—issues like extreme heat, flooding, or energy insecurity are deeply interconnected, impacting everything from public health to infrastructure, housing, and economic livelihoods. By breaking down silos between sectors and aligning strategies, integrated structures for planning and implementation enable a more systematic and cohesive approach, ensuring that adaptation measures are mutually reinforcing, resource-efficient, and capable of addressing the complex and interconnected nature of urban climate risks [88].

Case Study 9: Mukuru Special Planning Area's (SPA) integrated plans and governance structure helped the government to understand how a neighbourhood can be transformed using multi-sectoral strategies to foster resilience, rather than a single housing solution (see also Case Study 3). In Kenya, informal settlements are typically viewed narrowly as a housing issue, which falls under the responsibility of the Ministry of Transport, Infrastructure, Housing and Urban Development. Recognising the need for more holistic, joined-up responses, the SPA established eight consortia (see Figure 3, which maps against the Nairobi County Government departments). This helped to align national and local government and demonstrated to each local government department that they had a contribution to make. This catalysed a new way of thinking about the governance of informal settlements. The government no longer only envision a housing solution, but rather recognises that a neighbourhood can be transformed using multi-sectoral strategies to foster resilience.



iv) Working with networked organisations and approaches

Networked approaches offer a powerful means to bridge resource and capacity gaps and enhance adaptability across cities. Global and regional networks, such as the Asian Cities Climate Change Resilient Network (see Case Study 10 overleaf) have emerged or adapted their focus on climate action to support cities in achieving their resilience goals. These networks are vital

for creating synergies, fostering innovation, and ensuring that cities can address complex climate challenges more efficiently and sustainably than they could alone. These networks often act as systemic or innovation intermediaries, driving systems transformation through their:

- (i) shared mission and theory of change;
- (ii) trusted relationships;
- (iii) agility and adaptability;
- (iv) reciprocal knowledge exchange; and
- (v) local embedding and vertical aggregation.

Case Study 10: The Asian Cities Climate Change Resilient Network (ACCCRN)

The ACCCRN program, supported by The Rockefeller Foundation, exemplifies the potential and limitations of networked approaches. Over nine years, ACCCRN engaged more than 50 cities across six countries, focusing on building resilience in secondary cities and emphasizing the needs of poor and marginalised communities. The program's success was attributed to several factors:

- A clear mission in an emerging space of urban climate change resilience.
- The cultivation of local expertise, leadership, and ownership through network and facilitating institutions like ICLEI and Mercy Corps.
- Structured knowledge exchange through partner/member-led forums.
- Contextually adapted models supported by active national groups, avoiding a one-size-fits-all approach.
- Vertical aggregation of resources, demonstrated by the Rockefeller Foundation's support in launching a \$160 million multi-donor Urban Climate Change Resilience Trust Fund.

However, ACCCRN also highlighted the challenges of creating a singular, connected network. The program found greater success at the in-country level, where networks linked to pre-existing groups and structures, rather than attempting to maintain a multifaceted, overarching network.

Networked organisations have the unique ability to forge long-term partnerships with cities and trusted local actors, enabling them to align their collective missions more effectively. By connecting cities, networks facilitate the exchange of knowledge, resources, and best practices, thereby enhancing the capacity of individual cities to implement climate adaptation measures. At the same time, the diversity of actors involved enables the network to respond more adaptively to the evolving nature of climate risks.

Despite their potential, the effectiveness of these networks is often constrained by funding limitations and the internal capacity of local authorities. Networks that are well-resourced and capable of mobilising financial and intellectual resources can drive transformative change. However, when funding is inadequate or when local authorities lack the capacity to fully engage, the impact of these networks may be diminished.

Networks can also concentrate influence and resources in larger, more prominent cities, leading to unequal impact. These 'elite' cities, often with greater capacity and visibility, can dominate the agenda within networks, potentially reinforcing power inequalities and diverting attention away from smaller or less politically influential cities, particularly in the Global South. To mitigate this, there is an increasing recognition of the value of smaller cities as sites of innovation and leadership, particularly in specific geographic or thematic areas.

v) Data and action research gaps for delivery

Community-led and co-produced delivery

- What local capacity exists within communities, and how can it be harnessed and built upon to lead or co-produce climate-resilient initiatives? What capacity gaps need to be addressed?
- What are the most effective means of communicating climate risks to and within communities, especially in vulnerable or informal settlements, to empower them in the co-production of solutions?
- What are the best practices and key success factors of community-led initiatives? How can these be scaled up beyond just financing? How can improved resilience be demonstrated and measured within these communities?

Collaborative governance

- What mechanisms and approaches are most effective in promoting collaboration among diverse stakeholders (public, private, community) to enhance climate-resilient development?
- What are the key barriers (policy, regulatory, institutional) to collaborative approaches in urban adaptation, and how can these be addressed?
- What alternative models of participatory governance can effectively incorporate diverse actors (public, private, community) to support integrated climate action and generate climate action plans?

Integrated delivery mechanisms

- What approaches and strategies can be implemented to bridge silos between different sectors and levels of government for a more integrated delivery of climate-resilient interventions?
- What are the primary barriers to integrated approaches in urban planning and climate action (e.g., policy, regulatory, sectoral)? How can these be overcome?

Networked organisations

- What are the best practices for knowledge exchange within and between networked organisations to foster innovation and resilience in urban settings?
- How can networks avoid reinforcing inequalities by ensuring that smaller, less prominent cities are also supported and can contribute to, and benefit from, networked climate action initiatives?

Conclusion

Addressing extreme heat and climate risks in informal settlements requires a comprehensive, multi-faceted approach that involves strategic planning, innovative financing, and community-led delivery mechanisms. The vulnerabilities experienced by the 1.1 billion residents of informal settlements are compounded by socio-economic challenges such as a lack of access to cooling infrastructure, water, electricity, and healthcare. As the climate crisis intensifies, city stakeholders and decision makers operating across scales are uniquely positioned to drive impactful change by supporting initiatives that address these urgent interconnected challenges.

The entry points are multi-scalar and require action from networks of actors operating across scales, as evidenced in many of the case studies in this paper. International support is needed in relation to climate financing mechanisms that can reach the local level. Regional networks can support innovation and reflect specific socio-economic, political and spatial dynamics, for example processes of decentralisation in Latin American cities, and the complexities of tenure in sub-Saharan Africa. National governments can do more to devolve and decentralise decision making powers and resources to the local level; while local adaptation strategies need to be incubated by cities and decision makers or donors operating an international, regional and national scales.

One of the key opportunities is to support the co-production of participatory urban planning processes. By investing in local initiatives that collect and analyse disaggregated data on climate impacts in informal settlements, communities, local government and city stakeholders are well positioned to co-design targeted interventions that reduce exposure to extreme heat. For example, community-led research initiatives that map heat stress in vulnerable areas can inform policies that integrate green infrastructure, improve building design, and expand access to cooling systems. Support for participatory planning processes ensures that climate resilience strategies are grounded in the lived experiences of those most affected, promoting equity and sustainability.

Innovative financing mechanisms represent a critical entry point for action. In informal settlements, where public and international climate finance may be inaccessible, community-driven savings schemes can empower residents to implement adaptive measures and leverage additional resources. Meanwhile, innovative municipal financing mechanisms such as green bonds could finance cooling infrastructure, water management projects, and housing upgrades in vulnerable areas. Donors can also lend political support to the decentralisation of climate finance, ensuring that resources are directed to the local level, where they can be most effectively deployed. By investing in decentralised finance models that simultaneously support local actors to receive funds, donors can help overcome the 'missing middle' challenge, where small-scale pilot projects struggle to scale up to city-wide solutions.

Additional support is needed to enhance delivery mechanisms by supporting city level and community-led and co-produced adaptation efforts. Empowering cities and communities to lead the implementation of climate resilience strategies ensures that interventions are contextually relevant and tailored to local needs. Case studies from across the globe have demonstrated that community-led initiatives, when properly supported, can lead to transformative change in informal settlements. These efforts can be amplified by investing in collaborative governance models that bring together diverse stakeholders—governments, civil society organisations, and local communities—to implement integrated, climate-resilient development. This collaborative approach ensures that urban adaptation strategies are holistic, addressing not just heat stress but also the broader socio-economic challenges that amplify a range of connected climate risks.

Climate resilience is not just about mitigating risks; it is about addressing underlying inequalities and promoting sustainable development pathways that protect the most vulnerable. In the face of escalating climate challenges, it is essential that efforts to promote resilience do not leave the residents of informal settlements behind.

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Appendix – Glossary of key terms

- **Climate resilient development:** a framework that addresses warming and the impact of climate change through sustainable development pathways. Approaches prioritise ending poverty and associated inequalities through low-carbon and resilient investments that promote global and local equity.
- **Heat stress:** a range of conditions that leads to the failure of the body to adequately regulate temperature and is associated with negative health outcomes. Heat stress is associated with extreme heat and heat waves, which are defined and experienced differently across geographies. Generally, temperatures above 35°C using the 'wet-bulb' method (controlling for temperature, humidity, wind speed, sun angle, and cloud cover) is considered dangerous for the human body; however vulnerable populations can experience heat stress at lower temperatures.
- **Integrated climate action:** policies, programmes, and interventions designed to address adaptation and mitigation measures simultaneously and take advantage of social, economic, and environmental co-benefits. Integrated approaches can more effectively address development priorities of local populations, prevent maladaptation, and increase resources for adaptation measures.
- **Informal settlements:** unplanned and low-income areas of cities that are typically densely packed with self-constructed homes and lacking reliable public hard or soft infrastructure such as roads, sanitation, utilities, and services such as healthcare and education. Informal settlements are socially and economically heterogeneous, providing cities with much needed labour and filling in market gaps with informal service provision and small manufacturing. Settlements are often located in places vulnerable to climate and environmental hazards which is compounded by social, economic, and spatial inequalities. Terms 'informal' and 'slum' are not interchangeable, with informal commonly used to refer to any type of housing where occupants do not have legal claim to the land and fall outside government control or regulations. This may incorporate some 'slum' areas (as in SDG 11), which are defined principally in respect to their access to improved water and sanitation, sufficient living area, durability of housing, and security of tenure, rather than the legality of the settlement
- **Informal urbanisation:** the process of constructing urban housing, infrastructure and socio-economic systems outside formal state regulations and with little or no publicly provided services. Settlements and economies are built by networks of families and local actors and are often consolidated by different political negotiations and legal processes with the state. Urban informality is characteristic to cities globally and has been identified as one of the main processes of urbanisation in the Global South.
- **Maladaptation:** mostly unintended consequences of actions that lead to increased climate risks—included via higher GHG emissions — shifting vulnerability to new places or populations or reproducing or deepening inequalities that leads to diminished socio-ecological welfare.
- **Missing middle:** the difficult-to-access finance needed to replicate successful pilot projects and take innovation to scale, recognising the importance of soft infrastructure and capacity to ensure low-income communities benefit from investment in development and climate adaptation.

- **Participatory planning:** the inclusion of diverse stakeholders, including residents, in formal urban and development planning processes. Best practices of inclusive planning prioritise participation from excluded social groups early in the process and allow revision of objectives and implementation based on local contexts.
- **Soft infrastructure:** systems and processes that connect across governing and civil society institutions and actors and enable coordinated planning and governance for the socio-cultural, economic, and health wellbeing of a population. In the context of climate change, soft infrastructure can include early warning systems, climate finance readiness support mechanisms, public or engagement and awareness campaigns. We emphasise soft infrastructure as the [institutionalised] processes that facilitate learning, integrated planning, and collaborative climate action between diverse stakeholders within a city or network of cities and between city and regional/national governing actors.
- **Transformational adaptation:** climate action that fundamentally changes socio-ecological systems in anticipation of climate change. In this context, we emphasise addressing entrenched inequalities that increase climate vulnerability and compound risk. In urban environments, this means focusing on systemic changes to development processes that improve people's quality of life, enhancing the social and economic vibrancy of cities, and ensuring sustainable, resilient, and inclusive urban settlements.
- **Urban heat island:** the effect by which urban areas are hotter than the surrounding land areas due to land use, heat-trapping building materials, heat producing activities from industrial process and other human activities; the design of the built environment (including building size, street layouts, and green spaces), and reduced 'natural' cover of land (trees, grasses, and water). Depending on the climatic and physical geography of a city, the urban heat island effect can be 3–10°C and is often uneven across a city.

