Cities that Work

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IGC International Growth Centre

Embedding resilience: City responses to acute shocks and chronic stresses

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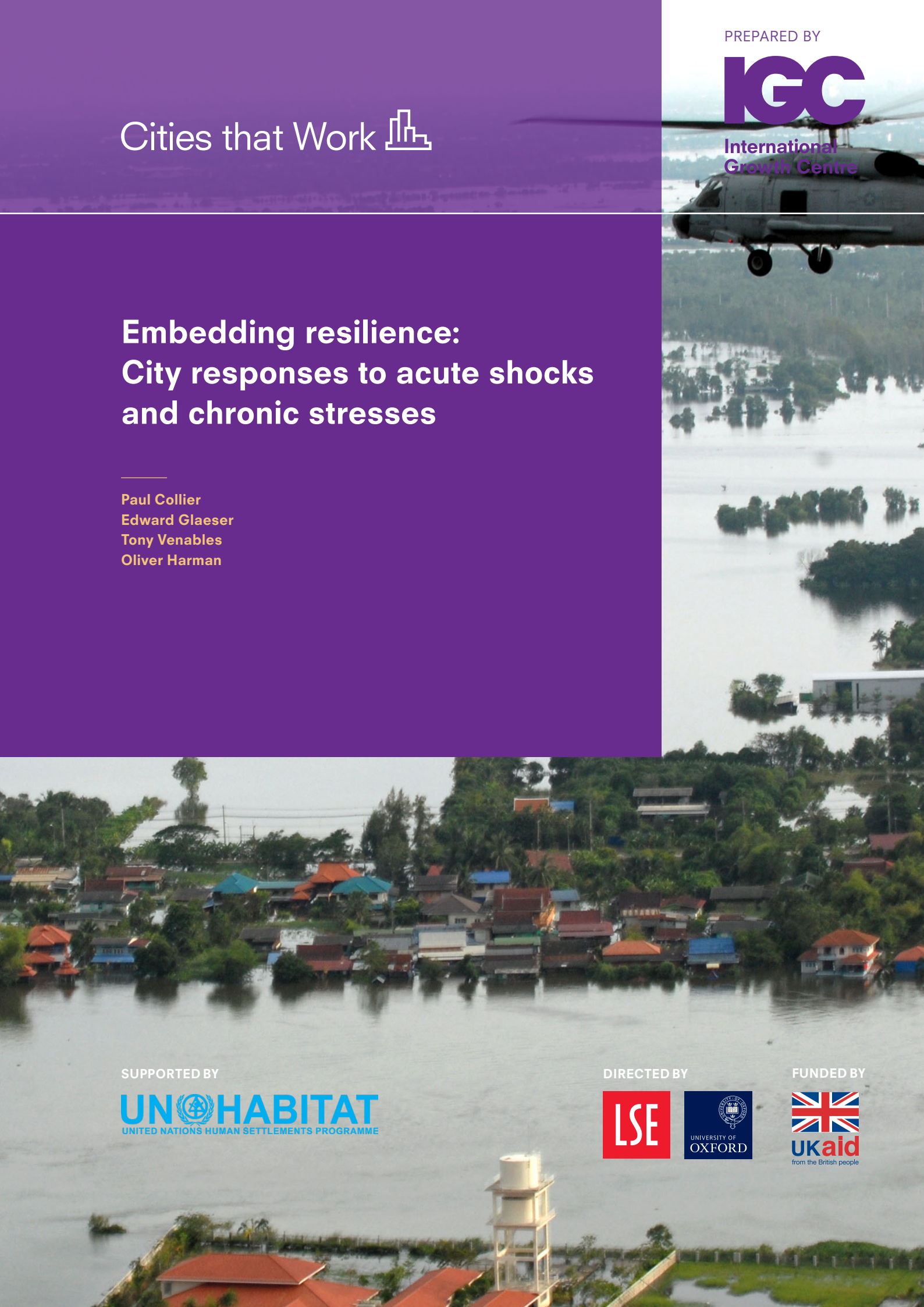

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"The best time to plant a tree was 20 years ago. The second best time is now."

(Chinese Proverb)

Executive Summary

Resilience to shocks comes from reducing exposure to them, and building cushions that manage them better. Acute shocks include seismic events, periodic heatwaves, droughts and flooding. Chronic stresses – in particular those associated with climate change -- build up in the longer term, increasing the frequency of acute shocks and creating their own chronic problems, such as sea-level rise. Estimates show that, if nothing is changed, the global economic costs to cities due to flooding and sea level rise alone will, by 2050, be about 1 trillion USD pa.

The impacts of acute shocks and chronic stress will unfold on different time scales, and policymakers need to act now with a view to establishing resilience in the short, the medium and the long term.

In the short term, there are acute challenges which require actions that deliver results fast. These include adaption measures to build government and community awareness and capacity for disaster response. A wider set of adaptation measures will yield results in the medium term. These include 'hard' measures, such as the construction of better infrastructure. As importantly, 'soft' measures such as building and land-use regulations, and regulatory schemes for traffic control and for water use need to be designed and put in place. Planning for long term change requires developing city foresight and flexibility. Data and knowledge management systems are needed, cities need to learn from others and, crucially, institutions need to develop in a manner that enables them to adjust and manage a radically different environment.

In parallel with adaptation, policies must seek to mitigate risks. Depending on context, mitigation policies may have longer run impacts, this reinforcing the case for early action. However, in many cases there are 'win-win' actions, delivering both short and long run benefits. For example, restricting the burning of fossil fuels has immediate health gains as well as long run climate benefit; greening of the urban environment mitigates the heat island effect, as well as acting as a carbon sink and reducing the need for air-conditioning.

Resilience and the Global Future Cities Programme

The FCO Global Future Cities Programme aims to promote sustainable, inclusive, and economic growth in 19 cities across 10 countries worldwide including Turkey, Brazil, South Africa, Nigeria, Indonesia, Malaysia, Philippines, Vietnam, Myanmar and Thailand. It aims to support the development challenges that arise with increasing rapid urbanisation, climate change and urban inequality, which can lower long term growth prospects of cities. By designing and implementing policy interventions in these cities to achieve the goals of urban policymakers, the Global Future Cities Programme aims to contribute significantly to achieving the Sustainable Development Goals (SDGs), in particular SDG 11 on Sustainable Cities and Communities, and implementation of the New Urban Agenda.

In response to the significant challenges faced by middle income cities in improving resilience and protecting vulnerable populations from shocks and stresses, resilience is one of the key pillars of the FCO Prosperity Fund's Global Future Cities Programme. This paper seeks to **frame and inform key areas of urban resilience policy**, based on economic research, cross country evidence, and on initial learnings from the Strategic Development Phase of the Programme. In this way, it seeks to provide an evidence base for future decision making in urban resilience.

In this paper

This paper considers the opportunities and challenges of urban resilience facing middle income cities before exploring the role of policy in reducing vulnerability to acute shocks and chronic stresses. In Section 1, this paper looks at the importance of resilience for policymakers and why action is needed now. Section 2 deals with adapting for now, policies necessary for dealing with today's shocks. Section 3 considers building and regulating for the future, action today that deals with tomorrow's challenges. Section 4 discusses how cities should deal with uncertainty and future change in decision making with planning and monitoring for the long run. Section 5 outlines some funding and financing opportunities for creating resilient cities that work before Section 6 concludes.

1. The importance of resilience

Resilience requires cities to reduce vulnerability to **shocks and stresses**.[1] The climate change literature[2] outlines these as acute shocks and chronic stresses, indicating the timeframes they impact within. **Acute shocks** are extreme events that are often localised, such as flash flooding in Dar es Salaam, Tanzania or earthquakes[3] in Coquimbo, Chile. **Chronic stresses** are the exacerbation of existing risks and the emergence of new risks emerging out of major climate change. Such examples are urban air pollution as seen in Beijing, China or urban heat islands as seen in Las Vegas, USA as well as sea level rise as seen in Mumbai, India and fresh water strain as seen in Cape Town, South Africa.

City growth and urbanisation will exacerbate these vulnerabilities. In particular, acute shocks are becoming an increasing problem. Since 1970 the number of disasters worldwide has more than quadrupled to around 400 a year. A large driver of this has been hydrological events experienced today at six times the frequency than in 1980.[4] Likewise, many of the world's largest cities are located in earthquake, storm and flood prone areas.[5] Historically cities developed near the coast and rivers. This was largely driven by the need for water, both for consumption and trade.[6] Adaptation and mitigation are critical as **climatic change** will disproportionately affect cities. Currently, 54% of global population lives in cities, estimated to rise to between 60% and 92% depending on the scenarios.[7] The combination of both increased exposed numbers and concentration of economic activity driving downsides of density[8] requires greater attention for cities. These issues are amplified through informal **urban development**. Approximately 180,000 people move to urban areas every day and 18% of all urban housing is non-permanent.[9] This makes it particularly vulnerable to the impact of extreme natural events. **The World Bank estimate by 2030 climatic pressures will push 77 million more urban residents into poverty.**[10]

Whilst chronic stresses underpin a city's vulnerability, acute shocks exacerbate it. As both stresses and shocks are often overlaid on top of each other, their **response requires coordination.** Furthermore, they need timeframes and a sense of place – where and when to act. Just as importantly adaption and mitigation actions must be realised as a benefit and not a drain to the city.

[1] Resilience generally is described by DFID as "The ability of countries, communities and households to manage change by maintaining or transforming living standards in the face of shocks or stresses without compromising their long term prospects". For cities, 100 Resilient Cities says "Urban resilience is the capacity of individuals, communities, institutions, businesses, and systems within a city to survive, adapt, and grow no matter what kinds of chronic stresses and acute shocks they experience".
[2] Wider literature on resilience referring to city revenues, migration, cyber attacks, violence, high unemployment or long term social decline amongst other issues is outside of the scope of this policy paper but does not negate its importance.
[3] Earthquakes, although not necessarily exacerbated by climate change do represent an acute shock to cities and are of interest in embedding resilience.
[4] The Economist (2017) "Weather related disasters are increasing"
[5] Institution of Mechanical Engineers (2013) "Natural Disasters: Savings Lives Today, Building Resilience for Tomorrow
[6] Many of the world's convergent earthquake fault lines run along similar paths where land meets sea.
[7] Jian and O'Neill (2017) "Global urbanisation projections for the shared socioeconomic pathways." *Glob. Environ. Change. 42,* pp193-199
[8] such as urban heat island, air pollution and susceptibility to flooding
[9] Ibid Institution of Mechanical Engineers (2013)
[10] World Bank Group. (2016). "Investing in Urban Resilience: Protecting and Promoting Development in a Changing World." *World Bank, Washington, DC*

Cost and opportunity – the case for action

It is estimated bold climate action **could deliver at least USD$26trillion in economic benefits through to 2030 compared to business as usual.**[11] City policymakers therefore have an economic development and social welfare requirement to implement cities resilient to climatic transformation.

"Policymakers should take their feet off the brakes, send a clear signal that the new growth story is here and that it comes with exciting economic and market opportunities. US$26 trillion and a more sustainable planet are on offer, if we act decisively now."
Ngozi Okonjo-Iweala
Former Finance Minister of Nigeria and Co-Chair of the Global Commission on the Economy and Climate

There are two key approaches for building urban resilience – adaptation and mitigation.[12] Combining these strategies and moving cities closer to being resilient can be a **catalyst for change**. For example, adaptation strategies to sea level rise have the opportunity to stimulate economic activity. Similarly, those around sea wall construction may stimulate local economic activity in the short term by providing activity and employment for local construction companies. Strategies around mangrove replanting have been shown to both stimulate local economic activity in the short term as well as providing longer term community revenues through fisheries, tourism and sustainable timber.[13] Mangrove replanting can also be a very effective mitigation strategy, as they can function as a carbon sink, storing two to four times the amount of carbon as forests.[14] This is just one example of how adaptation and mitigation as part of city resilient strategies can be economic city assets.

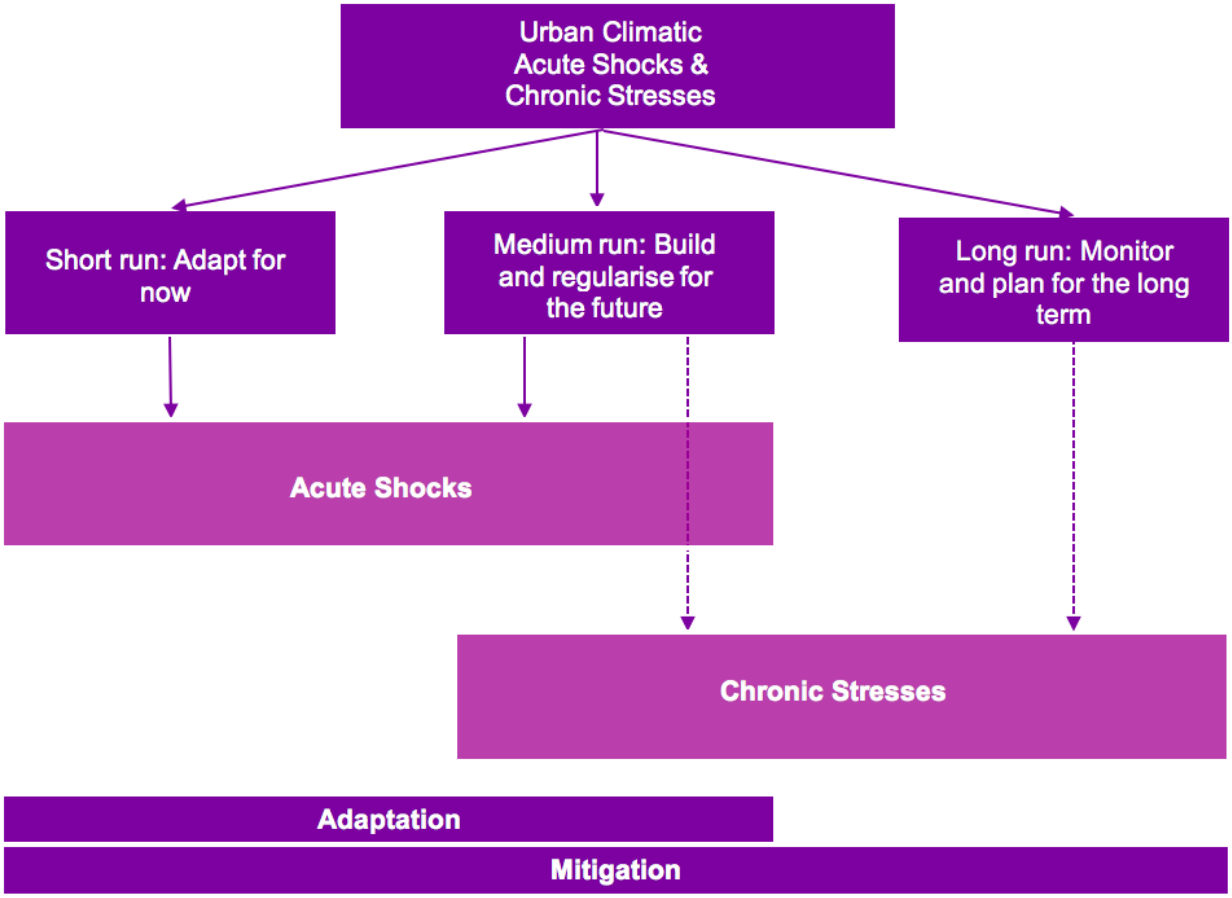
Global or local; now or never – where and when to act?

Acute shocks and chronic stresses are the problems we face, they offer useful insight into timeframes for action. Policies enacted now, but with a short term, medium term and long term view based on **adaptation and/or mitigation are the solutions.** In a world of scarce resources, we must efficiently deploy limited funds and personnel to deal with these concerns fully understanding the opportunity costs of doing so. Figure 1 provides an overview of timeframes that action and policies enacted today should address.

Climate change and natural disaster policies have a unique interaction with cities. Cities and their decision makers preside over defined and usually expanding, jurisdictions. Climate change, however, does not respect city boundaries. Therefore, when designing policies at a city level to effectively tackle climate shocks, policymakers must think about how the disaster or climatic change will affect not only their city but those regions around them. This will require coordinated action for effective response.

[11] New Climate Economy (2018) "Unlocking the Inclusive Growth Story of the 21st Century
[12] See Figure 1 and Page 12 for a more detailed outline
[13] Samonte, Primavera, Jurgenne & Edwards-Jones, Le Vay. (2006). "Are mangroves worth replanting? The direct economic benefits of a community-based reforestation project." *Environmental Conservation. 33*. pp335-343.
[14] Donato, Kauffman, Murdiyarso, Kurnianta, Stidham and Kannien (2011) "Mangroves among the most carbon-rich forests in the tropics" *Nature Geoscience, 4* pp293-29

Figure 1: Short, Medium and Long Run Policy Outcomes. Source: Author's Own



1. **Acute shocks**
    a. **Typically impact a particular spatial area**:[15] Acute shocks such as earthquakes or flash floods typically affect certain areas with certain direct and indirect difficulties. They require a specific response taken by city decision makers under whose jurisdiction (Mayor, Councillor) or department (water, disaster response) it falls under.
    b. **Are more short term in nature**: They are occurring now and are recurrent problems. Action is needed today with outcomes in the short to medium run. Acting on acute shocks is good to do now even if we manage to restrict climatic change temperature increases to 1.5 degrees[16] and these problems are not exacerbated in their nature. Adaptation strategies are the best first port of call for acute shocks, although must be used in coordination with mitigation to reduce future impacts.

2. **Chronic stresses**
    a. **Typically affect wider areas**.
        i. Although they are not always so directly quantifiable they are no less important. These stresses represent slowly intensifying problems that cities face. Chronic problems may be the air pollution from congestion or increased heat island effect due to more concrete infrastructure in

[15] Although are still often unpredictable in nature and scale particularly if poor national alert systems are in place.
[16] IPCC (2018) "Special Report on Global Warming of 1.5C"

the built environment. These problems may affect different areas of the city in different ways. Poor policy in one area may impact those elsewhere.

ii. Chronic stresses also suffer from negative externalities. Due to their wide spanning regional nature, the negative consequences of one city's action may affect a much wider geographic area. A useful example, expanded on in Section 4, is that of fresh water use. One city's unsustainable water use is likely to reduce aquifer levels for another city.

iii. Chronic stresses therefore too require specific responses. However, in this case, actors need to be more coordinated in their efforts. One city cannot bear all of the costs of chronic stresses if the benefits are felt at a wider scale. For example, coastal cities globally will be united in the consequences of sea level rise. They should therefore be united in their action.

b. **Are longer term in nature:** The costs and impacts may be exacerbated in the future with the impact being felt in the long run. Strategies for change are therefore needed today with outcomes in the medium to long term. Acting on chronic stresses are necessary in tandem with more pressing consequences from acute shocks. Mitigation strategies therefore play a more critical role with respect to chronic stresses.

When framing resilience decisions, city policymakers should think of the spatial nature of the problem and the timeframe over which their policy response is trying to unfold. **If it is an acute shock then it may be unique to their jurisdiction. If it is a chronic stress their response may need wider coordination.**

2. Adapting for now; the short-run

Adapt for now initiatives are necessary to respond to current and reoccurring issues in the city and deal with existing adaptation deficit. Even if there is no further climate change, these initiatives help deal with today's problems. **They therefore represent a policy response with short term outcomes**. Properly designed and delivered, they are low regret since there is certainty around the issue they deal with – it is already happening to the city. It is important to highlight that they often address just the symptom rather than the root of the problem. Underlying chronic change will need further action. Adapting for now is useful in areas which are already getting acute shocks they cannot cope with. These are decisions for today. Some examples are:

- Capacity building in disaster preparedness at national and local government level e.g. coordinating plans and training staff;
- Livelihoods programmes for marginalised groups e.g. security nets;
- Investments in disaster preparedness e.g. ensuring population know the correct response for when a disaster occurs.

How can capacity to respond quickly and effectively to shocks be built?

Building capacity needs to be undertaken at both the national and local level. Responses to acute shocks require the governance structures to work in a coordinated fashion.[17] Supporting local structures and participation are both critical components in building resilience.[18] Capacity building can take a number of forms. For embedding resilience, it may involve skills development for disaster response, relief planning training or cross government workshops as having empowered and coordinated institutions reduces vulnerability.

1. Reaction to acute shocks needs to be based on forward planning and coordinated capacity building

Case study: The need for coordinated capacity, Concepción, Chile

The 2010 earthquake in Concepción's metropolitan area highlights this need for coordinated plans. Although strong building codes ensured a limited loss of life, key services such as electricity, water, sewerage and communication lines were disrupted and

"The 8.8 magnitude earthquake destroyed buildings across the city" Source: BBC/Getty Images

[17] For more detailed discussion on resilience and governance structures see cluster paper Malik, A (2018) 'Can cities become more resilient?'
[18] UNOCHA Position paper: Resilience

came to a standstill. This interruption made the city unable to respond and direct relief efforts. Furthermore, disaster relief services at the national level in Santiago were unable to communicate with city decision makers, local officials or indeed the public. The lack of pre-emptive capacity building of adequate personnel at the city level meant without electricity and communications services, those at the central government level were not able to issue orders. This led to rioting, food shortages, and panic. Training and coordination are therefore essential, but with a focus on the interaction between governance levels.

2. **Capacity building is needed in the community as well as in government.** Capacity building of the population helps to ensure quick and effective responses to shocks. Low cost and easily initiated, improving knowledge of pre-disaster awareness and post-disaster response are effective in lessening negative outcomes.

Case study: Effective community partnership with city government in Iloilo City, Philippines and Quelimane City, Mozambique

Iloilo City, Philippines and Quelimane City, Mozambique both highlight how effective community partnership with city government has increased community's ability to adapt to acute shocks. In the Iloilo City, through community mapping and creation of partnerships, city leaders were able to work with local civil society to increase the resilience of vulnerable groups. Going into communities, highlighting those in need as well as key stakeholders to implement change has allowed transformation to be inclusively driven from the bottom. Government and community together, organised relocation of these vulnerable groups away from flood risk, all driven by community priorities.[19]

"Iloilo City Mayor. Communion of Communities with Señor Santo Niño" Source: Clark Villaruel Antiquiera

In the Qualimane City, most of which is below the sea level, the administration has brought resilience initiative ownership to local communities. One example extends from the challenges of keeping drainage systems clean. Through education and engagement,

[19] Dodman, Mitlin, and Co. (2010) "Victims to victors, disasters to opportunities: Community-driven responses to climate change in the Philippines." *International Development Planning Review 32*(1) pp 1-26.

the challenges and solutions regarding community wellbeing and resilience related to drainage were outlined. Mindset and behavioural changes of communities were also targeted. These groups then see the benefit of this new asset and have bought into the process of care. The successful approach was similarly taken with mangrove replanting around coastal areas of marginalised groups reversing the trend of timber harvesting.

These initiatives have led to more effective service delivery with communities demonstrating their willingness and ability to input into city resilience. This knowledge and participation are crucial to ensure government actions reach and meet citizen needs.

Empowering local communities to implement relevant changes ensures longevity and embeddedness of resilience. Communities and policymakers need to break the cycle of putting-off resilience.

What is the role of rapid response safety nets in addressing acute shocks?

Governments are able to reduce adverse shocks from climatic impact by ensuring rapid response safety nets are in place. Supporting households through subsidised health goods or direct transfers have a particularly important role to play in urban areas, especially for ensuring quick adaptation.[20] Safety nets deal with many of the negative indirect mechanisms such as reducing the ability to work and lowering income that can lead to wider negative outcomes.

Focusing climate funds on reaching local communities, rather than the wider slower-moving institutions, is one that can deliver a quick triple win[21], as local programmes are able to produce sustainable results at a:

- ✓ lower cost – local procurement provides cost savings
- ✓ developing local capacity – from putting local governments at the helm of development efforts
- ✓ generating climate positive local economic development benefits – the injection of funds offers a climate relevant strategic boost to the local economy and workforce[22]

These benefits such as access to cleaner energy, reduced pollution and improved livelihoods are quick wins regarding city adaptation.

[20] Maddalena, Gentilini, and Yemtsov. (2015) "The state of social safety nets 2015." Washington, DC: World Bank Group (2015)
[21] Soanes, Rai, Steele, Shakya and Macgregor (2017) “Delivering real change - Getting international climate finance to the local level.” *IIED Working Paper*
[22] Dunning (2013) “Is Local Spending Better”. *Centre for American Progress*

Case Study: Disaster Adaptation Community Funding in Bangladesh and Kenya

At the local level, The Bangladesh Local Disaster Risk Reduction Fund and Kenya County Climate Change Fund (CCCF) have proven successful in implementing local climate change adaptation. The former provides grants through local government, which are used for community designed and implemented projects in disaster adaptation. This is combined with longer term climate change planning. Examples include raising ground above flood levels and emergency access routes to emergency shelters. With local ownership and support from line Ministries, the local resilience and development opportunities have improved. 820,000 people have benefitted from 249 disaster adaptation schemes with 80,000 finding employment as a result. Crucially the gains have been two-way: local and national government structures have also seen capacity increase as these bottom up context specific responses have increased their cross government understanding. Key lessons learnt and successful strategies are transferred across ministries and local governments back down to other communities suffering similar circumstances.

"A women-led community council prepares a 'social map' of the local community"
Source: Naimul Haq/IPS

Kenya's country and local level approach is similar. The CCCF enables local communities to share learning dialogues at ward and county level. Proposals are developed in tandem, the procurement of goods is consulted upon and the monitoring of change happens at ward level. This adds to their knowledge of local climate resilience. Local adaptation decision making is improved and the mobilisation of county (provincial, regional) funds follows. It is estimated that less than 10 per cent of climate finance is prioritised for such local driven solutions.[23] Reallocation of such spending would be a quick and easy way for urban decision makers to improve city resilience. The success of the CCCF model has already seen it replicated in Mali, Senegal and Tanzania.[24]

[23] Soanes, Rai, Steele, Shakya and Macgregor (2017) "Delivering real change - Getting international climate finance to the local level" *IIED Working Paper*
[24] Kiiru (2016) Accessing climate finance in Kenya. Available at <https://www.iied.org/accessing-climate-finance-kenya>

How can cities both plan for the long term and respond effectively in the short term to acute shocks?

There are two main ways in which policymakers can address natural shocks and stresses: mitigate now for tomorrow's stresses or adapt now for today's shocks.

- **Mitigation Strategies:** Examples of mitigation strategies include the reduction of greenhouse gas emissions or rebuilding areas that capture carbon such as forests.
- **Adaptation:** These are adjustments to the human system, for example, with the building of flood barriers or extending flood insurance to high risk areas.

Adaptation is likely to be especially important for developing cities since these areas are predicted to be dealing with the largest effects of climate change.[25] **City policymakers must decide how to effectively combine their decisions with regards to resilience. Utilising strategies focused on either mitigation, adaptation or ideally a balance of both.**

Mitigation

- ✓ More economical than adaptation; prevention is far cheaper than dealing with the effects of a shock[26]
- ✓ Deals with the root causes of long term climatic change
- ✓ Benefits are felt not just within the city, but reduction in climate change inputs are experienced globally

Yet mitigation strategies suffer from:

- × Slower impact and thus they are not as useful in dealing with the acute shocks happening to cities today
- × Coordination problems as those who bear emission reduction costs may be different from those to benefit from emission reductions
- × Being a global public good. Climate change mitigation does not have shorter term direct impact on the city, instead, a longer term impact benefitting a wider group
- × Perceived economic compromise of leaving fossil fuels in the ground

Adaptation

- ✓ Is a local private good, benefitting only the city that invests in adaptation[27]
- ✓ Cities can better manage their existing climate issues
- ✓ May stimulate local economy through increased economic activity
- ✓ More direct tangible results

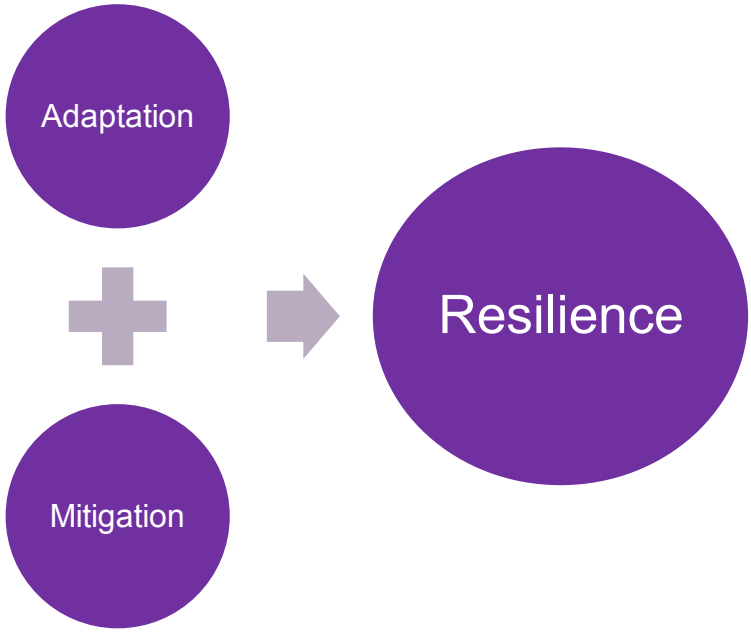
[25] Cole (2008) "Climate Change, Adaptation, and Development", *UCLA J. Envtl. L. & Pol'y*, *26*, 1.
[26] See discussion in this paper on What kinds of infrastructure investments help to enhance resilience?
[27] Hasson, Löfgren and Visser. (2010) Climate change in a public goods game: Investment decision in mitigation versus adaptation, *Ecological Economics*, *70*(2), 331-338,

Yet adaptation strategies have their drawbacks as well:

- In face of changing and rising climate change, adaptation for today may be different from adaptation tomorrow
- Adaptation does not get to the root of the problem
- May have cost of adaptation now and cost of re-adaptation tomorrow

As noted, effective long term city resilience, therefore often requires a mixture of both adaptation and mitigation. City policymakers thinking about the necessary adaptation should think about what changes can lead to long term mitigation. For example, changing consumption attitudes can be useful as a short term reactionary measure to address acute shocks in a way that can also be leveraged in the long term. A city suffering from water scarcity may want to dramatically reduce consumption initially, also altering use onto a more sustainable path in the long run. Sao Paulo, Brazil (see case study) and Cape Town, South Africa[28] are useful examples to draw lessons from. Similarly, a combination of weather patterns and pollution may lead to a city suffering from acute bouts of smog. Efficiently framed pollution reduction incentives may be able to reduce pollutants in the short run but also change behaviour, mitigating the shock in the long run.

As with many responses to acute shocks, working with engaged citizenry is beneficial. The combination of these approaches in tandem will add to sustainable city resilience.



[28] See Cape Town's Preliminary Resilience Assessment Available at < http://resource.capetown.gov.za/documentcentre/Documents/City%20research%20reports%20and%20review/CCT%20PreliminaryResilienceAssessment.pdf>

Case Study: Responding to water crisis with short term adaptation and long term mitigation in Sao Paulo, Brazil

In São Paulo, during the 2015 water crisis, the worst drought in more than 80 years brought major city reservoirs to dangerously low levels down to 27% in 2015 from 40% in 2014.[29] The issue was perpetuated by poorly serviced informal settlements polluting other reservoirs. Reacting to this, the city government and motivated individuals together stepped in. Although the city was experiencing an acute shock, the initial response took a long term perspective. The state-controlled water utility company, Sabesp, proposed construction of new reservoirs and drawing of water from nearby river basins. A megaproject and process that would take over 18 months and which lacked the short term reaction necessary.

Upon realisation this long run policy was insufficient, Sabesp developed an immediate short term solution. The company decided to give residents discounts on their water bills to incentivise the reduction of consumption. Small reductions would receive small discounts (up to 10% reduction for a low concession), however, larger reductions would receive ever larger discounts (more than 20% would receive a 30% concession). These reductions had significant effects in the short term with more than 80% of city residents complying with the scheme. Average consumption fell 20%.[30]

This short term change in behaviour also had long lasting benefits. In 2018 water consumption has remained 10% lower than 2015 levels – even with sufficient supply in

"Illegally built slums on the border of the polluted water of Billings reservoir in São Paulo" by Reuters (2015)

place. Sabesp can now approach the longer term solutions to the chronic stresses the city is facing regarding water. A water resources fund now diverts water users' funds to building and regulating for the future. Schemes such as plugging inefficient pipelines and building water collection tanks for informal settlements to ensure storage security are now being put in place.

[29] Ross (2015) "São Paulo Drought 2015" Available at: https://www.ibtimes.com/sao-paulo-drought-2015-photos-historic-water-crisis-brazil-show-city-brink-collapse-1912767 Accessed <2nd October 2018>
[30] C40 Cities "Restoring the Flow" Available at: https://www.c40.org/other/the-future-we-don-t-want-restoring-the-flow <Accessed 24th September>

The São Paulo case shows the critical interconnectedness of both acute shocks and chronic stresses and the need to conjoin policies both in the short term and long term.

Greater financial reach: Acute shocks represent an unfortunate but timely opportunity for city leaders to expand the financial reach of their budgets. In responding to such difficulty, funding from the national and international communities is often more forthcoming. Cities must use this opportunity not just to build back, but to build back better. An example of such funding is the World Bank's Deferred Drawdown Option. Disbursing funds within hours for short term disaster relief as well as tied technical capacity building to ensure longer term adaptation. Adapting the city as it is today and mitigating the city for tomorrow.[31]

[31] For further discussion and tools for building back better see https://practicalaction.org/build-back-better

3. Building and regulating for the future

Building and regulating for the future represents resilience development decisions where the **outcome is felt in the medium term**. Decisions taken today will be exposed to climate change in the future. In building and regulating for the future, therefore, both acute shocks and chronic stresses can be alleviated. Building represents 'harder' measures with regulating covering the 'softer' decisions. Some key examples of responses with medium term benefits are:

- Critical infrastructure where losses and repair costs will be high – for instance hospitals and bridges
- Long lived infrastructure – those that will be expensive to retrofit later
- Decisions that are 'locked in' for some time – such as urban plans

Building better

What kinds of energy infrastructure investments help to enhance growth and resilience?

As highlighted in Concepción's case study, the lack of electrical provision after an acute shock compounded the problems experienced. Flooding presents a particular risk to urban power supplies. Many power stations are located in flood-prone areas as it represents a cheap and easy supply of cooling water. If the power supply is compromised, everything ranging from transportation to heating and hospitals become at risk.

"Flood damaged areas in Tanzania" by Col. Robert Kaiser (2010)

As such, a key infrastructure investment that can enhance resilience and mitigate this is the decentralisation of renewable electrical provision.[32] Rio de Janeiro, Brazil, for example, is working towards a localised energy matrix that has the co-benefit of being low-carbon (mitigation) and addresses flood risks (adaptation). Setting targets to source more energy from decentralised renewable sources this approach both enhances adaptability to any acute shocks (flooding) and chronic stresses (sea level rise). It also mitigates difficulty in future by reducing greenhouse gas emissions. Decentralised renewable energy provision has the linked co-benefits such as improving air quality, local job creation and city empowerment of its own energy supply. It represents both adaptation, longer term mitigation solution as well as driving economic growth by increasing skills of the workforce and decreasing lost economic activity. Countries suffering power outages lose sales value and with most consumption occurring in cities this is where diminished economic activity is disproportionately felt.[33]

[32] C40 Cities "Powering Cities in the face of climate change"
[33] It is estimated in Ghana 2-6% of GDP is lost through intermittent power. See https://www.theigc.org/project/vicious-circle-power-outages-bill-payment-evidence-ghana/

Pre-emptive infrastructure investment: Such investments in infrastructure must critically happen pre-emptively rather than post-disaster. Infrastructure is costly to retrofit. **It is estimated every $1 spend on building preparedness and resilience can save as much as $4 in relief, recovery and reconstruction later.**[34] [35] If not done pre-emptively, the negative consequences are considerably larger.

Furthermore, those vulnerable populations more at risk to climate change often reside in areas of poor infrastructure provision. When under shock or stress, this poor foundation amplifies the likelihood of disease spreading. Policies focusing not only on pre-emptively tackling infrastructure gaps, but improving local infrastructures such as informal roads and informal housing should make the greatest steps in enhancing resilience.[36]

How can cities build to mitigate temperature rises?

Increasing global temperatures do not affect all areas equally. In particular, **cities are likely to face larger rises in temperatures as a result of urban surfaces such as roofs and pavements.** Recent studies show over 200 million people in 350 cities suffer average daily peak temperatures of 35°C for three months a year[37], which is on average 8 degrees warmer than their rural counterparts.[38] This is largely due to urban surfaces such as roofs and pavements routinely being heated up by the sun to temperatures 27°C – 50°C hotter than the air.[39] This effect is felt both during the day and at night with city structures releasing stored heat after sunset. As cities expand over time, this heat island effect also tends to become more intense.

Population growth, rural-urban migration and emission growth will intensify this vulnerability to heat. **The urban population at risk from these high temperatures will be over 800% higher and reach 1.6billion by 2050.**[40] For example, during the 2016 heatwave, the number of patients in India's hospitals doubled. Europe's 2003 heatwave led to 70,000 deaths. Economic activity also suffers. Manufacturing and construction output has been known to drop 20% in heatwaves due to reduced productivity.[41] This productivity reduction is expected to globally cost USD$2trillion by 2030.

Policymakers have two types of instrument to mitigate the urban heat island effect; building better and enhancing the natural environment.

<u>Enhancing the built environment</u>

There are a number of greening initiatives that both adapt to and mitigate against urban heat island effect. Critically, in many cases these initiatives allow public and private landlords to charge more for their buildings, representing an opportunity rather than a cost. A study of

[34] Institution of Mechanical Engineers (2013) "Natural Disasters: Savings Lives Today, Building Resilience for Tomorrow pp3
[35] Triveno. (2017) Presentation at 2017Urban Resilience Summit.
[last accessed 25th September 2018]: Available at< http://pubdocs.worldbank.org/en/372321500955142392/World-Bank-Housing-LMT-Low.pdf>
[36] Picarelli, Jaupart and Chen (2017) "Weather shocks and health in Dar es Salaam" IGC Working Paper C-40404-TZA-1
[37] C40 Cities "For Cities the heat is on" [Accessed 14th July] Available at: < https://www.c40.org/other/the-future-we-don-t-want-for-cities-the-heat-is-on>
[38] Kahn (2017) "This is how climate change will shift the world's cities" [Accessed 18th August] Available at: < http://www.climatecentral.org/news/global-cities-climate-change-21584>
[39] Gartland (2012) Heat Islands: Understanding and Mitigating Heat in Urban Areas" *Earthscan*
[40] (Author's calculation from C40 Cities). In many cities this rural – urban migration itself is driven by climatic issues such as crop failure and food insecurity.
[41] IPCC (2014) "Climate change 2014" Available at <https://www.ipcc.ch/report/ar5/>

Los Angeles estimated a $1 billion investment in enhancing the built and natural environment would see annual benefits of $170m in reduced electrical load and $380m in smog related health savings. This represents a net benefit to the city in two years.[42] A non-exhaustive list of options is as follows:

- ✓ Green/brown roofs[43]
- ✓ Reflective roofs[44]
- ✓ Cool pavements[45]
- ✓ Green parking lots[46]

Both cool and green roofs, for example, provide benefits lower surface and air temperatures as well as decreased energy demand.

Case study: Building codes and cool roofs in Changwon, South Korea

By being part of the C40 network allowing discussion and learning from other cities who have implemented cool roof programmes, Changwon subsidised a pilot programme utilising reflective surfaces on building roofs. This was a technique borrowed from Tokyo, Japan. In improving their heat reduction measurements, the city was able to accelerate and target cooling in the city. This reduced the urban heat island effect and vulnerability to extreme heat waves. Adaptation for the city had a tied mitigation benefit in that it reduced the use of air conditioning and thus reduced greenhouse gas emissions.

Enhancing the natural environment

Greening the city: Trees and vegetation moderate heat islands and also improve residents' comfort. This is typically in three ways:

- ✓ Shading
- ✓ Evapotranspiration
- ✓ Wind shielding.[47]

Shading helps reduce the amount of solar radiation transmitted through their canopy and can cool built environment peak temperatures from between 5°C to 20°C[48]. As trees also transfer water vapour back to the atmosphere, further urban heat island mitigation is found.[49][50]

Greening the city, particularly the benefits from urban trees, has wider benefits such as increasing neighbourhood property values, reducing air pollutants and managing storm

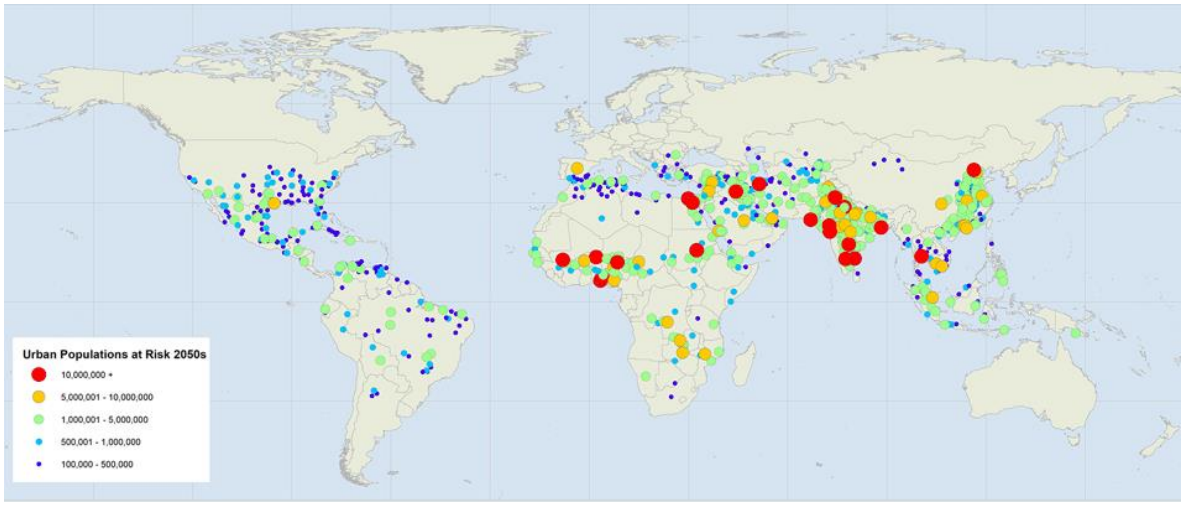
[42] Rosenfeld, Romm, Akbari and Lloyd (1997) "Paint the Town White – and Green" *MIT Technology Review*
[43] See https://www.epa.gov/heat-islands/using-green-roofs-reduce-heat-islands
[44] See https://www.epa.gov/heat-islands/using-cool-roofs-reduce-heat-islands
[45] See https://heatisland.lbl.gov/coolscience/cool-pavements
[46] See EPA's "Green Parking Lot Resource Guide"
[47] Huang, Hashem and Taha (1990). "The wind-shielding and shading effects of trees on residential heating and cooling requirements"
[48] Meier (1990). "Measured cooling savings from vegetative landscaping. Proc. American Council for an Energy Efficient Economy, Environment, 4. Pp133 - 143
[49] Huang, Akbari, and Taha. (1990) "The Wind-Shielding and Shading Effects of Trees on Residential Heating and Cooling Requirements." *ASHRAE Winter Meeting, American Society of Heating, Refrigerating and Air-Conditioning Engineers*.
[50] Kurn, Bretz, Huang, Akbari. (1994). "The Potential for Reducing Urban Air Temperatures and Energy Consumption through Vegetative Cooling (PDF)" *ACEEE Summer Study on Energy Efficiency in Buildings, American Council for an Energy Efficient Economy. Pacific Grove, California*.

water, thus reducing urban flooding.[51] **In California, there has been $5.82 in return on investment for every $1 spent on tree planting and maintenance.**[52] Over 80% of this return is on increases in property value.[53] Despite these large potential benefits, funding and financing of such greening of the city is still an issue for many urban areas. This is due to four key reasons.

1) **Lack of knowledge on benefits** – both decision makers and public
2) **Public concerns about potential negative problems** – e.g. fear of untended parks providing space for criminal activity
3) **Government silos** – although tree planting benefits many parts of urban fabric, it is often uncoordinated and left to an agency responsible for forestry
4) **Lack of financial resources** – trees are considered a luxury good rather than a city asset

One recommendation for city decision makers is to coordinate with national actors such as ministries of health, as their budgets are often larger. Furthermore, city resilience and health benefits such greening provides has good precedence to be funded at a national level. **Greening the city has the key benefit of adaptation combining positively with mitigation.** Predominantly playing a role in reducing urban temperatures, it also plays a further important role in being a carbon sink, thus drawing greenhouse gases from the atmosphere. Cities can effectively use urban planning in conjunction with greening methods such as planning for green wedges.[54] Key urban areas at risk are highlighted below in Figure 2.

Figure 2: Urban populations at risk from heat extremes in 2050. Source: C40 Cities



Cities with a three-month period (consecutive months) when projected average maximum temperatures exceed 35°C

[51] The Nature Conservancy (2017) "Funding Trees for Health: An Analysis of Finance and Policy Actions to Enable Tree Planting for Public Health"
[52] McPherson, van Doorn and de Goede (2015). "The State of California's Street Trees" *Pacific Southwest Research Station,* US Forest Service: Davis, CA.
[53] To see how cities can benefit from this rise, see Collier, P., Glaeser, E., Venables, A., Manwaring, P., and Blake, M. (2018) *Land and property taxes: exploiting untapped municipal revenues*. IGC *Cities that Work* Policy Brief.
[54] For other policies to mitigate urban head island effect see UNHabitat (2015) Integrating Climate Change into City Development Strategies. <Available https://unhabitat.org/books/integrating-climate-change-into-city-development-strategies/>

Regulating better

How can zoning laws be utilised effectively for resilience?

In many emerging countries, enforcement of planning and zoning laws is weak. An estimated 860 million people live in slums often provisioned with limited infrastructure and on cheap dangerous land.[55] **The use of zoning laws can be an effective means of regularising this.** Helping their movement to less vulnerable areas and preventing future relapse. Zoning also falls well into the local government's actionable jurisdiction. It is local government's responsibility for designing and enforcing such frameworks that contribute to public wellbeing.[56]

Figure 3: Reduction of local economic activity in the year of flood. Source: Author's Own, based on data from Kokornik-Mina et al (2015)

"local economic impact of large floods, on average, they reduce a city's economic activity by between 2 and 8 % during the year of the flood." Kokornik-Mina et al (2015)[57] pp3

The need for zoning laws arises as people often inhabit high risk areas, even returning to them after acute shocks. Research shows that even in the case of frequent flooding:

- **Economic activity does not shift away from the danger areas**
- Post disaster there is no significant adaptation
- Those vulnerable locations are slowly refilled unfortunately setting the scene to repeat itself
- Populations remain under high risk in perpetuity as they have embedded themselves with a sense of place
- The city loses economic output (See Figure 3).

The extent to which people return depends on their estimate of flood risk, the availability of alternative land, and the value of assets remaining (for example, remaining infrastructure and buildings). Effective zoning policy should take all these factors into account, and restrict such building in the first place.

For city policymakers who have inherited cities where this opportunity was not taken, pre-disaster action can still mitigate the risk to vulnerable populations. Although zoning itself is an important tool, it is only useful if effectively implemented. The first step in doing so is to

[55] Marx, Stoker and Suri (2013) "The Economics of Slums in the Developing World", *Journal of Economic Perspectives, 27*(4), pp. 187-210.
[56] Dodman and Satterthwaite (2008) "Institutional capacity, climate change adaptation and the urban poor". *IDS Bulletin, 39*(4), pp 67-74
[57] Kocornik-Mina, McDermott, Michaels, Rauch (2015) "Flooded Cities", *CEP Discussion Paper No 1398*

ensure that zoning is **realistic.** However complimentary measures to enhance compliance come in three main forms: [58]

1) Increasing costs of delinquency
2) Reducing costs of compliance
3) Building support for planning

Case study: Land Rights and Zoning in Dar es Salaam, Tanzania

Dar es Salaam's response to sea level rise and flooding has been two-fold. Firstly, the city has restricted construction in flood risk areas, particularly inhibiting the spread of vulnerable informal settlements. In order for these restrictions to be effective, in tandem, they have formalised property rights in less vulnerable areas in order to incentivise families to evacuate flood prone neighbourhoods. Through regularisations and pre-emptive planning, as families move to these new safer areas, the city also provides water supply, drainage, sanitation, transport and all other basic infrastructure services.

Dar es Salaam draft available areas for city expansion. Source: RAUF

As more families move, a virtuous cycle of increasing land values and further provision of infrastructure sees property prices increase. However, this attempt to reduce vulnerability is not clear cut. Lack of enforcement and potential financial gain does result in some relocated families selling their formalised properties and moving back to the better connected neighbourhood of origin.[59]

[58] For more information see Collier, Glaeser, Venables, Manwaring. (2018) "Urban planning for productive and liveable cities." *IGC Cities that Work Policy Paper.*
[59] For a wider insight into zoning laws and land use planning, please see IGC's Cities that Work Urban Planning Paper. Collier, Glaeser, Venables, Manwaring (2018) "Urban planning for productive and liveable cities". *IGC Cities that Work Policy Paper.*

What effective regulation policies have been put in place to reduce air pollution?[60]

Air pollution can represent both an acute shock and a chronic stress to a city. For example, congestion and industry can provide ever increasing particle matter in a city's air. When it is combined with unique weather circumstances, this can become a short term difficulty. Such conditions were prevalent in Delhi, India in 2017 with slow winds and colder temperatures blamed for a surge in airborne pollutants. The pollutants caused transport delays, schools to be shut, widespread health problems and overall economic difficulty.[61] Deaths from pollution dwarf many other causes (e.g. Tobacco, AIDS, malnutrition) with the brunt being borne in developing and emerging countries. In 2015 alone, poor pollution prevention led to 3.2 million South East Asian deaths.[62] Cities, which account for 85% of global economic activity, concentrate people, energy consumption, construction activity industry as well as traffic in a dense space. Therefore, as well as being of the key drivers of pollution's growth, they also deal considerably with the negative effects.[63]

Air pollution can be usefully alleviated at a city level, particularly through regulations. For example, one of the key drivers of air pollution is that of traffic and congestion. **Across all cities private transportation generates more than 40% of cities' greenhouse gases, rising to 70% in medium sized cities.**[64] Reducing this is critical for the health and wealth of cities. The health benefits are clear.[65] Estimates of wealth benefits show every dollar invested in the control of ambient air pollution in the USA yielded $30 in economic benefits.[66] Without regulation, private vehicle users do not internalise the costs of their behaviour on the wider urban environment. This is likely to be particularly harmful in central areas of dense cities, where private vehicles contribute significantly to congestion. In order to reduce transport congestion, and to incentivise private vehicle users to switch to use of public transit services, there are two main types of regulation policymakers can use:

1) **Putting an additional price on private transport.** This can be done by imposing a quota on car ownership and allowing users to bid over user-rights, as seen in Singapore. The alternative is to impose an additional price on travel, which travellers can respond to by adjusting their use. Policymakers can impose additional charges directly for vehicle use, through congestion charges where private vehicles pay a daily fee to drive in particular urban areas. They can also charge users indirectly, for example through fuel taxes or parking permits.
2) **Quantity restrictions on vehicle ownership or usage**. These can be direct restrictions such as limits on vehicle licenses, high-occupancy vehicle restrictions that regulate the number of people in a car and odd-even number plate policies that

[60] A more detailed discussion on transport regulation is available at IGC's Cities that Work Transport Paper. Collier, Glaeser, Venables, Manwaring (2018) "Access to opportunity: urban mobility for prosperous cities"
[61] Safi (2017) "Delhi doctors declare pollution emergency as smog chokes city" Available at: https://www.theguardian.com/world/2017/nov/07/delhi-india-declares-pollution-emergency-as-smog-chokes-city <Accessed 2nd October>
[62] Lancet (2018) "The Lancet Commission on pollution and health", *Lancet 2018, 391,* pp 462 - 512
[63] Wilkinson, Smith, Beevers, Tonne, Oreszczyn (2007) "Energy, energy efficiency, and the built environment." *Lancet 2017, 370,* pp1175-1187
[64] Lall, "Planning, Connecting, and Financing Cities - Now."
[65] See https://aqli.epic.uchicago.edu for city analysis
[66] US Environmental Protection Agency: Office of Air and Radiation. The benefits and costs of the Clean Air Act from 1990 to 2020. Found at <https://www.epa.gov/sites/production/files/2015-07/documents/summaryreport.pdf>

only permit certain vehicles to use roads on particular days, or indirect restrictions such as parking space restrictions in a city.

Case study: Quantity restrictions on use in Quito

In Quito, Ecuador, a similar *Pico y Placa* program has been associated with a reduction in carbon monoxide ambient concentration of around 9 -11% during peak hours, and 6% between 6am and 8pm on working days, suggesting similar magnitudes of reduction in vehicle flows in the city. Though after the initial 20 months of implementation its effect has diminished due in part to more vehicles as a result of population growth in the city, the programme has been found to still have an effect in reducing pollutants with limited evidence of behaviour to circumvent regulations.[67]

3) **Offer ecological public transport alternatives to residents.** Just regulation will not be sufficient. A city must offer greener alternatives. Therefore, in tandem with restrictions and regulation, subsidies may be a useful tool to shift demand to ecologically sustainable transport alternatives.

Case study: Transport subsidies and Bus Rapid Transit (BRT) in Mexico City, Mexico and Bogotá, Columbia

The costs of air pollution are not internalised by private agents and therefore city leaders may choose to subsidise cleaner transport. This combined offering will encourage the switch.

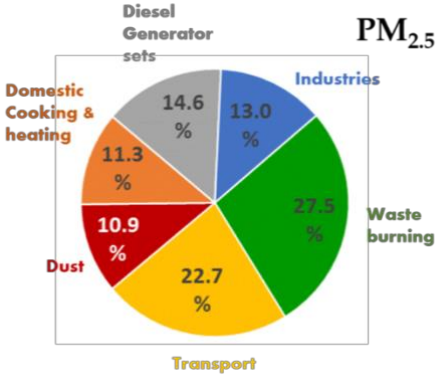
In Mexico City, for example, the system for BRT is expected to generate $3million each year in health benefits from reduced air pollution. Similarly, in Bogotá, the first 30 years of BRT has seen local air pollutants reduce by 40%. This is in addition to the improvement in travel time compared to the transport system otherwise available.[68][69]

4) **Drive for density.** Dealing with how many cars are on the road and the nature of their fumes is one necessary approach. However, the other approach is how far the cars are travelling. Zoning changes bringing in more mixed residential commercial zoning to cut commuting times can also reduce particle pollution.[70] However, there are other costs such as forgoing efficiency and liveability gains as externalities are not fully captured. From a resilience perspective, mixed use zoning should only be seen as a short term relief solution.[71]

[67] Carrillo, Malik, and Yoo, "Driving Restrictions That Work? Quito's Pico Y Placa Program."
[68] Lee (2003) "TransMilenio Bus Rapid Transit System of Bogota, Columbia." *UNEP Collaborating Centre of Energy and Environment, Roskilde, Denmark.*
[69] Mojica and Gómez-Ibáñez (2011) "TransMilenio: The Battle Over Avenida Septima" *Harvard Kennedy School*
[70] Mohan and Tiwari (2000) "Mobility, environment and safety in megacities" IATSS Research
[71] For more on zoning and land use planning please see the Cities that Work policy paper on Urban planning for productive and liveable cities Collier, P., Glaeser, E., Venables, A., Manwaring, P. (2018) "Urban planning for productive and liveable cities." *IGC Cities that Work Policy Paper.*

Not all air pollution is transport related. Industries and electrical provision also have key roles to play and research shows how innovative regulations can reduce this pollution as is outlined below in the case study on Indian cities.[72]

Case study: Poor Electricity Provision and Air Pollution in Indian Cities



PM2.5 Multi-City Indian Samples. Source: CPCB (2010)[1]

PM2.5 represents the fine particle matter pollution. They are the main cause of visibility and pose the greatest city health problems. A multi-city survey of Indian cities shows that although a large contributor to air pollutants, transport is not the highest. Waste burning represents the most significant driver of pollution. However, after these two and with a higher pollutant output than industry are diesel generator sets.

The provision of decentralised frequent clean energy therefore is a win-win-win. Not only does it adapt the city's susceptibility to natural disasters, it also should see the reduction of air pollution through more infrequent diesel generator use and mitigation of long term emissions.

Cost effective ways to reduce carbon

Some interventions may dramatically reduce carbon emissions but may be high cost. Others may have smaller carbon effectiveness but are cost effective saving the city money in the long run. In making decisions cities must calculate and weigh up these alternatives.

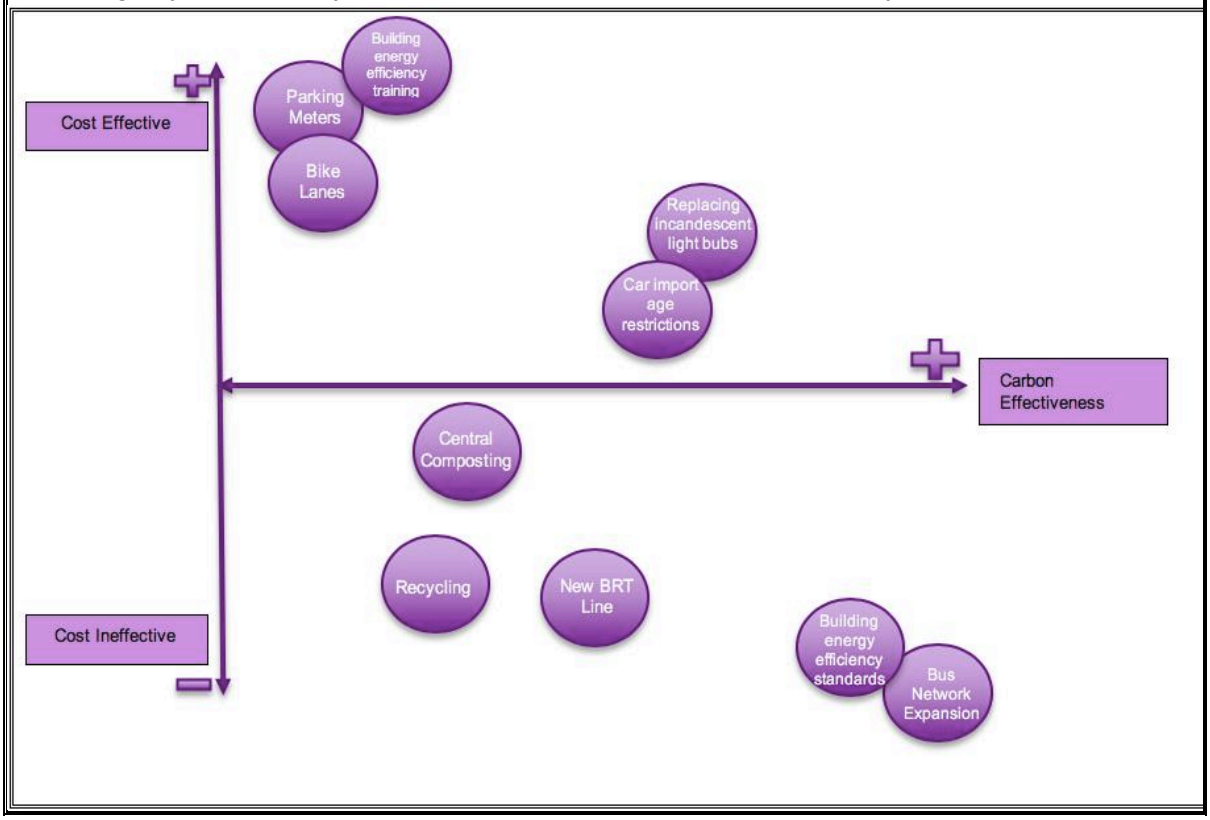
Case study: The Economics of Low Carbon Cities. Kigali, Rwanda

A recent study of Kigali, Rwanda[73] looked at potential low carbon policies for the city and showed a number of options available to mitigate against future emissions. The study calculated **10.1% of the city's GDP was leaving its local economy every year through payment of its energy bill,** money lost from the city economy rather than being reinvested**.** The study showed, with 0.6% of GDP invested, every year for ten years instead**, the city could profitably gain from exploiting economically attractive energy efficient and low carbon opportunities – marking carbon resilience as a growth opportunity**. Calculations were made on the trade offs between carbon effectiveness and cost effectiveness. The former representing the estimated amount of carbon saved by implementing the policy. The latter representing the extent to which energy saving investments would pay for themselves over their lifetime – generating positive budget flows for the city.

Some opportunities such as adding more geothermal rather than solar to the energy mix or replacing all incandescent light bulbs were both highly carbon and cost effective.

[72] Please see https://www.theigc.org/impact/innovative-regulations-reduce-pollution/
[73] Gouldson, Colenbrander, Sudmat, Chilundika and De Melo (2018). "The Economics of Low Carbon Cities, Kigali, Rwanda"

Others had a trade off for policymakers. Parking meters, for example, are cost effective. They pay for themselves in economic benefit. However, they may not be as carbon effective as other changes in the city. The removal of idling cars and inner city congestion in Kigali will have a smaller effect on carbon released than for instance building energy efficiency standards. In this case however, the cost is more ineffective with large investments required and less payback to the city. One intervention is not necessarily better than another, they both have different benefits. This must be accounted for when reducing city vulnerability. Some of the opportunities are indicatively outlined below.



4. Planning and monitoring for the long run

Planning and monitoring for the long run should be a critical part of a city's resilience strategy. These are the **decisions made now that will help future policy makers deal with the consequences of large scale climate change.** If city decision makers are to break the cycle of poor resilience planning then resources must be placed in this area. Planning and monitoring set the foundation for more informed decisions now and tomorrow. These choices today also matter as they affect the locking in of resilience strategies. Some examples include:

- Adaptive management development strategies that are able to adapt to new information
- Early research on areas of potential difficulty later for instance flood resistance crops
- Data centres to help inform future decision making
- Investment in long term monitoring and generation of weather data

What are the future resilience challenges cities must plan for in the long run?

Two major city resilience challenges of the future revolve around water. The lack of fresh water and the excess of salt water. Both problems require **collaboration across city, regional and trans-national boundaries**. Both problems also require substantial planning and monitoring in the long term. They are chronic stresses for which a long term lens is required.

Fresh Water

Low and middle income cities are undergoing considerable population growth. Africa's population of 1.1billion is expected to double by 2050 with more than 80% of that growth occurring in cities.[74] The strain on water resources will be wide spread. By 2050, the **demand for water is expected to increase by 50 per cent,**[75] however, this will be disproportionately felt in urban areas with urban water demand due increase by 80% by 2050.[76] **More than one billion urban residents may face water shortage in the future owing to urbanisation and climate change.**[77] This is a critical risk to life.

Fresh water provision represents a unique challenge for city decision makers. Aquifers do not respect national boundaries, let alone city jurisdictions. They are drawn upon from numerous users leading to two types of strain.

1. **Cross Municipality Strain.** Cities both within countries and across countries draw upon the same water sources. It is critical for city to city leaders to plan and monitor shared supplies. Cities who are projected to overstretch water supplies have two types of solution.
    a. **Hard adaptation solutions** such as transporting water from beyond city boundaries or desalination. The former is estimated to cost $0.06 cubic meter

[74] Muggah and Kilcullen (2016) https://www.weforum.org/agenda/2016/05/africa-biggest-cities-fragility/
[75] UN Convention to Combat Desertification
[76] Flörke et al (2018) "Water competition between cities and agriculture driven by climate change and urban growth." *Nature Sustainability*.
[77] IPCC (2014) "Climate Change 2014: Impacts, Adaptation, and Vulnerability" (eds Field, C. B. et al.) pp 535–612.

of water[78]. With the latter energy intensive costing up to $0.81 per cubic meter for production.

b. **Soft mitigation solutions** such as landscape management and more efficient water use. Removal of non-native water intensive tree species has been useful to increase groundwater recharge in South Africa.[79]

There is therefore a clear need for data on water supply and demand in cities. Planning, monitoring and forecasting are critical tools to adapt and mitigate against water chronic stresses.

2. **Cross Sector Strain.** Both urban and rural areas require fresh water provision for varied agricultural, manufacturing and service based industry inputs. **In 41% of all river basins by 2050, the needs of agriculture will conflict with those of cities.**[80] There will not be enough water to supply both. The potential for food shortage or urban water stress is high. This issue will be particularly prevalent in South Asian regions where water competition between rural-urban is highest.[81] Therefore, interaction and cooperation between rural industry and urban decision makers leading to efficiency gains is critical. Partnership and engagement leading to 10% increase in productive use should free up enough water for urban growth in 80% of tested high conflict watersheds.[82]

Investments in improving agricultural water use could thus serve as an important global change mitigation strategy. However, they require planning and monitoring.

Case study: Data driven decision making for resilience in Cape Town, South Africa

The City of Cape Town with assistance from the UK Foreign and Commonwealth Office's Prosperity Fund is coordinating a data platform for evidence based decision making. Cape Town is suffering a water crisis, beginning in 2015 with declining dam levels leading in April 2018 for 'Day Zero' to be announced – the day Municipal water supply would be largely shut off. Although water levels have been replenished, water management, cross cutting a number of themes, is still required. Particularly how the city can harness detailed and timeous data to monitor water infrastructure, support decision making. The new data will be visible and accessible allowing the public's collective understanding and ability to mitigate against long term water challenges.

[78] Kally and Fishelson (1993) "Water and Peace: Water Resources and the Arab-Israeli Peace Process". *Praeger*
[79] Zimmermann, Moran and Hoffmann. (2004) "Biological control in the management of invasive alien plants in South Africa, and the role of the Working for Water programme." South African Journal of Science 100 pp34–40.
[80] Flörke, Schneider and McDonald. (2018) "Water competition between cities and agriculture driven by climate change and urban growth. *Nature Sustainability*.
[81] Ibid above
[82] Ibid above

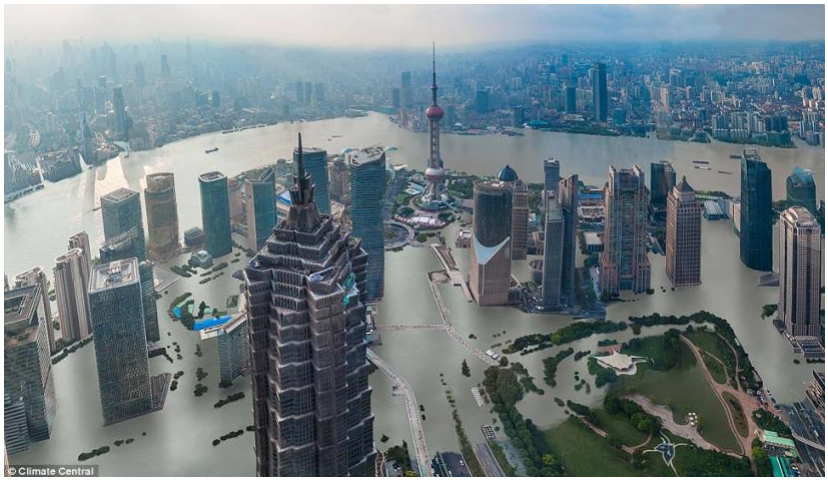
"Cape Town approaching 'Day Zero'". Source

This platform will help the City of Cape Town plan and monitor in the face of future uncertainty. As the city further urbanises, population strain combined with climate change may alter water provision. This data driven foresight should help better decision making and will build on the City of Cape Town's globally recognised strategy balancing water resources, demand and wastage.[83]

Salt Water

Sea level rise is another major resilience challenge facing cities in the long run. Climatic changes through sea temperature rise, current changes and melting icebergs has led to estimates that by 2050 **over 800 million people will live in cities at risk of flooding from sea level rise and associated storm surges** (See Figure 4). **The global economic costs to cities could amount to $1 trillion by 2050.**[84] The global rise of one metre in sea level rise once predicted for 2100 is now expected by 2070.[85] This rise will not be felt equally with some cities; for example, since 1900, New York has experienced twice the rate of sea level rise compared to the global average (1.2 inches per decade compared to global 0.6 inches).[86]

[83] For more information please see http://resource.capetown.gov.za/documentcentre/Documents/City%20research%20reports%20and%20review/CCT%20PreliminaryResilienceAssessment.pdf
[84] Goering (2018) "Cities face dramatic rise in risks from heat and flood by 2050, researchers say". Available at Thomson Reuters Foundation News
[85] Ibid
[86] New York City Panel on Climate Change 2015 Report Executive Summary



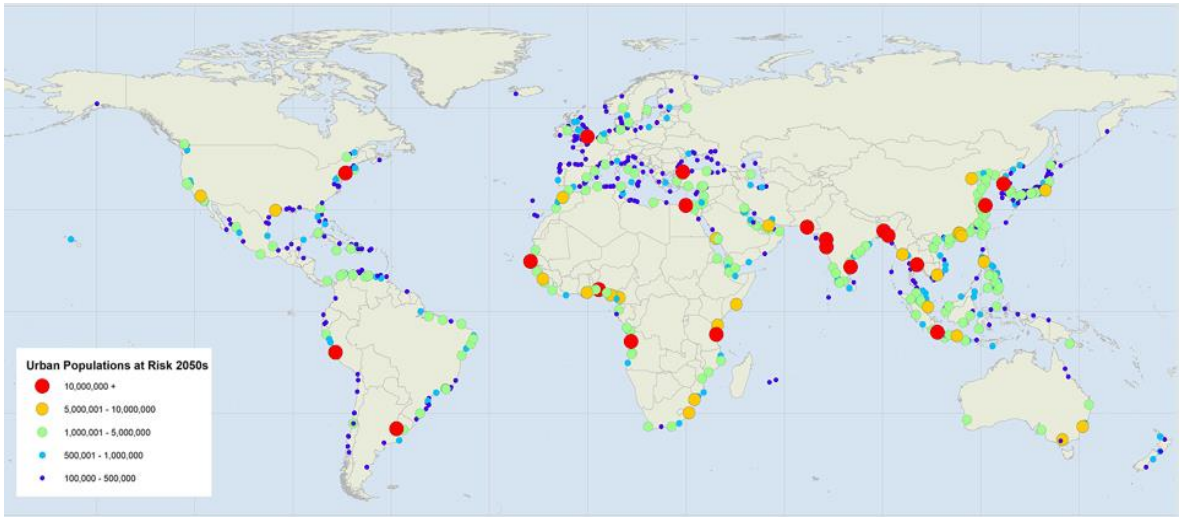
Shanghai Under Sea in 100 Years by Climate Central (2010)

The nature of this slow chronic stress means cities must plan and monitor for the long run – making decisions today the outcome of which may not be felt for years. In many areas of the city, adapting, building or regularising will be ineffective. Many industries will disappear. Mombasa, Kenya, for example, could lose 17% of its land, areas currently extensively used for tourism.[87]

Case study: Planning for the long run in Jakarta, Indonesia

It is estimated that Jakarta has 10 years to halt its submergence. If unchecked, millions of residents will lose their homes, the built environment will be underwater and the country's main economic hub crippled. In planning against this the city has developed a city-wide climate adaptation strategy. Short term adaptation measures include building a sea wall. However longer term adaptation plans require the relocation of at risk residents. This major relocation needs planned phased participatory changes driven by data.[88]

Figure 4: City populations at risk from 2050's sea level rise. Source C40 Cities



There are a number of useful tools that cities can utilise to help identify key challenges they will be facing in the future. **Once city challenges and key vulnerabilities are understood, then more effective planning and monitoring can take place.** This evidence base will help efficient and coordinated use of resources.

[87] UNHabitat (2011) "Cities and Climate Change: Global Report on Human Settlements 2011"
[88] For more information on data for urban planning, see Landry, Jean-Noé (2018) "Data systems for urban planning and land management" UNHABITAT

Toolbox: Planning Tools for Urban Disaster and Climatic Resistant Resilience

There are a number of tools that aim to help frame a city's resilience strengths and weaknesses. Although these tools available to urban policymakers do not properly account for city contextuality, they can provide a useful first step in thinking about resilience and road-mapping vulnerability reduction.

UNHabitat Tools

a) Disaster Resilience Scorecard for Cities[89]

The online scorecard provides cities an opportunity for local governments to monitor and review progress and challenges in the implementation of the *Sendai Framework for Disaster Risk Reduction: 2015-2030*. Particularly to assess their disaster resilience.

b) Urban planning guide for climate change[90]

A framework tailored to low and middle income countries where the challenges of planning for climate change are particularly high.

c) Guiding Principles for City Climate Action Planning[91]

Principles intended to be applied flexibly in order to support local officials, in climate action resilience planning. Both in mitigating greenhouse gas emissions and adapting, building local climate resilience.

d) City Resilience Profiling Programme[92]

An initiative where a number of stakeholder partnerships allows focus for national and local governments tools for measuring and increasing resilience to multi hazard impacts, particularly those associated with climate change.

The Compact of Mayors[93]

Networks are powerful tools for cross city learning, participation in best practice and thus overall coordination of mitigation and response. The Compact of Mayors builds on a commitment of 9,000 cities to lead to a low emission and climate resilient future. The body represents the world's largest coalition of city leaders registering their mitigation and adaptation commitments, taking inventories, setting reduction targets and creating action plans.

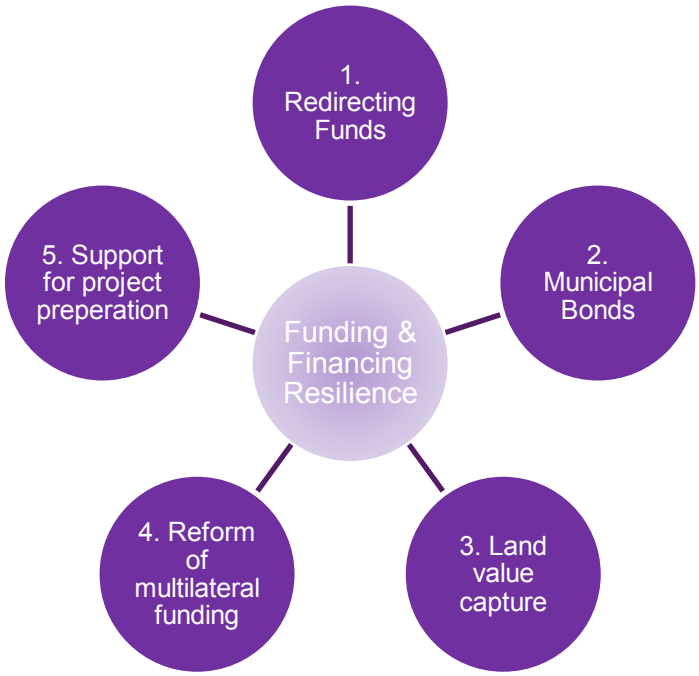
City Resilience Index[94]

This Index based upon 156 qualitative and 156 quantitative data points, helps cities assess and measure metrics on Economy & Society, Infrastructure & Ecosystems, Leadership & Strategy and Health & Wellbeing. The Index provides a baseline understanding of resilience at that precise moment and it useful for cities to compare their performance over time as well as better facilitate inter-city dialogue and knowledge sharing. Cape Town has effectively used the City Resilience Index to plan for the future alleviating current resilience gaps.[95]

[89] See www.unisdr.org/we/inform/publications/53349
[90] See https://unhabitat.org/books/planning-for-climate-change-a-strategic-values-based-approach-for-urban-planners-cities-and-climate-change-initiative/
[91] See https://unhabitat.org/books/guiding-principles-for-climate-city-planning-action/
[92] See https://unhabitat.org/urban-initiatives/initiatives-programmes/city-resilience-profiling-programme/
[93] See http://www.compactofmayors.org/
[94] See http://www.cityresilienceindex.org
[95] Kesson, Morgan and Green. (2018). "Resilient Cape Town: Preliminary Resilience Assessment"

5. Funding and financing resilience

Funding resilience represents a key part of a city policymakers' decision, particularly regarding mitigation or adaptation strategies. It is also a key challenge, particularly in cash strapped low and middle income cities. The *New Climate Economy 2014 Report*[96] outlines various funding options highlighted below and successful examples of their implementation.



Redirecting funds: The movement of funds away from the standard business as usual scenario can be a useful way of developing city resilience. It reduces the investment gap. The highly successful Bus Rapid Transit System in Bogotá, Columbia, for example, was partially financed through funds otherwise earmarked for urban highway programmes in this way. However, these funds must be ringfenced to implement plans. Implementation of *Flood Action Plan* in Dhaka, Bangladesh was incomplete as expected funds were not ringfenced. One important Western Embankment was successfully completed, however, another perceived less important Eastern embankment saw funding eroded and was not built.[97]

Municipal bonds: Cities can pool a number of projects together to form a collective group of assets that can underwrite issuing a bond. This mechanism is not available to all cities as only 20% of the largest 500 emerging country cities are creditworthy in local markets. However, in some cities, green municipal bonds have been successfully issued. The World Bank's City Creditworthiness Initiative is a useful tool to demonstrate how cities may get closer to issuing Municipal bonds. Johannesburg, South Africa, for example, issued a green Municipal bond for USD$126m capital investment to invest in hybrid buses, rooftop solar water heaters and biogas energy. However, Municipal bonds do increase the city's level of indebtedness and borrowing can be a risky action.[98]

[96] New Climate Economy (2014) "Better Growth, Better Climate: The New Climate Economy Report"
[97] Bird, Yue, Rahman, Rama, and Venables. (2018) "Toward Great Dhaka: A New Urban Development Paradigm Eastward." *World Bank*
[98] See Freire and Kopanyi (2018) "Asset and debt management for cities" *IGC Policy Note* for further discussion

Land value capture: The capture (or sharing) of land value increases from resilience investments can be very effective to finance many 'building and regularising better' initiatives.[99] Sao Paulo, Brazil, for example, has raised over $1.2billion from 2008 – 2014 from land value capture. Similarly, in linking high density mixed use spaces with the conversion of their highway into a BRT corridor, decision makers in Curitiba, Brazil have co-funded the investment. Land value capture, however, can be politically and legislatively difficult to implement if existing preconditions do not exist.[100]

Reform of multilateral and bilateral funding: Much multilateral and bilateral funding comes through national governments to the cities. However, more direct engagement that cities can take with such agencies will provide effective avenues for potential funding. Some types of multilateral funding available for urban adaptation and mitigation includes GEF Small Grants Programme; ADB Climate Change Fund; Climate Investment Funds; Global Climate Change Alliance; UNFCCC Adaptation Fund; Green Climate Fund; Cool Earth Partnership. However, multilateral and bilateral funding reform will require longer term engagement between local, municipal and central government levels.

Support for project preparation: Although not a direct financing mechanism, leveraging international support for resilience project preparation and financing is critical in lower capacity environments. If not, private partners will either not be interested, or will over extract value from the city. The Cities Development Initiative for Asia (CDIA)[101] assists mid-sized cities to bridge the gap between development plans and implementation. Private Public Partnerships (PPPs) may be another area for cities to explore in this context.[102]

Greater budgetary control: Not a direct funding option, longer term discussion around the devolution of financial autonomy to cities is necessary. This transfer of authority could enable them to leverage co-financing that is required for larger scale resilience investment. Whilst it does not negate the need for central government fundraising, cities enabled to both raise own source revenues and effectively access international funding streams should allow more accurate responses to resilience risks.

Decentralised funding is more effective than top down allocation. Bilateral and climate funds that focus on local programmes can deliver a triple-win:

- ✓ More sustainable results at lower cost
- ✓ Developing local capacity
- ✓ Generating climate-positive local economic development benefits e.g. improved livelihoods, reduced pollution and clean energy access.[103]

[99] For deeper discussion see IGC's Policy Brief Land and property taxes for municipal finance. Collier, Glaeser, Venables, Manwaring and Blake (2017) "Land and property taxes for municipal finance" IGC Policy Paper
[100] See Collier. (2016) "African Urbanisation: An Analytic Policy Guide." *IGC Policy Brief* for land value discussion regarding Africa and Siemiatycki. (2018) "Options for financing and funding transportation infrastructure" *IGC Policy Brief* for land value discussion regarding transport infrastructure
[101] CDIA (the Cities Development Initiative for Asia) is an international partnership between the Asian Development Bank (ADB), the Government of Germany, with additional core funding support from the governments of Austria, Sweden, Switzerland and the Shanghai Municipal Government.
[102] Siemiatycki (Forthcoming) Strategies for Effective Procurement and Public-Private Partnerships in the Transport Sector. *IGC Policy Brief*
[103] Soanes, Rai, Steele, Shakya and Macgregor (2017) "Delivering real change - Getting international climate finance to the local level" *IIED Working Paper*

6. Concluding remarks

"Every country makes commitments to make this world better. The cities are where really we deliver results."
Michael Bloomberg Co-Chair of Covenant of Mayors and UN Special Envoy for Cities and Climate Change

Resilience for urban environments represents unique opportunities despite some challenges. Incorporating resilience into cities represents a growth potential and should be viewed as such.

Climatic problems come in either the form of acute shocks or chronic stresses. Therefore, their solutions are found in either adaptation or mitigation, but ideally a combination of both, in one of three ways:

- ✓ Policies with short term benefits
  - Adapting for now: focused on local adaptation to acute shocks
- ✓ Policies with medium term benefits
  - Building and regulating better: focused on a combination of local adaptation to acute shocks and wider mitigation to chronic stresses
- ✓ Policies with long term benefits
  - Planning and monitoring in the long run: focused on global mitigation to chronic stresses

The policies with effects in the long term must account for unknown climatic development. They must build in flexibility to their solutions.

Each city is unique in its challenges and solutions. There are tools, frameworks and networks all available to help craft these responses. However, these top down solutions must be combined with engaged community responses to truly develop resilient cities.

City resilience can come in many forms. Resilience to city revenue decline, migration, cyber attacks, violence, high unemployment or long term social decline amongst other issues. In order to have useful policy discussion, the narrow focus on climate resilience was taken. This doesn't however negate the importance of others. Focusing on climatic resilience, this paper draws upon some key responses city decision makers can take. In tackling climatic acute shocks and chronic stresses they must both account for city boundaries and global limits. Adapting to local problems as individual city leaders and mitigating against global change as a coordinated unit must be the solution. Only then will cities have truly embedded resilience.

7. Recommended further reading

- Gartland (2012) “Heat Islands: Understanding and Mitigating Heat in Urban Areas” *Earthscan*
- Jha and Block (2012) “Cities and Flooding: A Guide to Integrated Urban Flood Risk Management for the 21st Century.” *World Bank*
- International Growth Centre (2018) “Innovative regulations to reduce pollution.” Found at: https://www.theigc.org/impact/innovative-regulations-reduce-pollution/ <Accessed 2nd October>
- Intergovernmental Panel on Climate Change (2018) “Global Warming of 1.5$_{o}$C: Summary for Policymakers”
- Clarke and Dercon (2016) “Dull Disasters? How planning ahead will make a difference” *Oxford University Press*

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