C40 CITIES

Integrating Climate Adaptation

A toolkit for urban planners and adaptation practitioners

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Global Platform for Sustainable Cities

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Appendix

C40 Cities

C40 is a network of the world's megacities committed to addressing climate change. C40 supports cities to collaborate effectively, share knowledge and drive meaningful, measurable and sustainable action on climate change.

Around the world, C40 Cities connects 96 of the world's greatest cities to take bold climate action, leading the way towards a healthier and more sustainable future. Representing 700+ million citizens and one quarter of the global economy, mayors of the C40 cities are committed to delivering on the most ambitious goals of the Paris Agreement at the local level, as well as to cleaning the air we breathe.

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Introduction

Today, over half the world's population lives in cities and that number is expected to rise to more than two-thirds by 2050.[1]

Cities are not only a key *contributor* to climate change – being responsible for 70% of greenhouse gas (GHG) emissions[2] – they will also bear the brunt of the climate crisis' *effects* and, to a large extent, are already doing so. The global temperature has now risen by 0.8 degrees Celsius[3] and, even if the goal of the Paris Agreement[4] is reached and the temperature rise kept below 1.5° or 2°C, the consequences for cities will be extreme. An increase of 2°C by 2050 threatens to place 1.3 billion people at risk and destroy USD 158 trillion in assets – double the annual productive output of the world – due to climate-change-related natural disasters.[5]

Cities accommodate most of the worldwide population vulnerable to climate change, and this represents a tremendous opportunity: by adapting cities, climate risks can be addressed and vulnerable lives and assets protected. As urbanization continues to accelerate, the increase in the frequency and severity of climate risks in cities becomes more and more visible. However, what could be a vulnerability is also an opportunity to adapt. Urban planning, which determines the conditions under which urban development takes place, is crucial to creating a future where people, vital services and infrastructure are more resilient against climate risks. C40 Cities has identified a need for urban planning and adaptation practitioners working for the city to exchange knowledge and work more effectively together in accelerating climate change adaptation.

Urban development is a key factor in how climate risks, such as floods or the urban heat island, affect a city. Labelling these 'natural disasters' ignores the extent to which a sprawling, impervious built environment exacerbates climate hazards. As urban populations have expanded, so have cities onto wetlands and other flood-prone areas. The costs of not controlling urban expansion onto land vulnerable to climate hazards as well as not taking bold climate adaptation action will be dire. However, the effort required to improve urban planning and climate adaptation integration is within arm's reach. The benefits of doing so are far-reaching. Sustainable urban planning policies, once in place, can mitigate climate risks for decades to come.

Aimed at both urban planning and climate adaptation specialists working for cities, this toolkit was developed with the goal of facilitating the inclusion of climate change adaptation principles into the practice of urban planning. It is meant as a guidance document for cities to set themselves up for success in the emerging field of climate-change adaptation through urban planning measures. It is understood that urban planners are not always adaptation specialists, and city staff focussing on adaptation may lack knowledge about urban planning, but given the certainty of climate-related hazards, both disciplines must adapt in order to come together. Urban planning projects must incorporate natural vulnerabilities – flooding, drought, etc. – as well as nature-based solutions to ensure practical, liveable, and just development.

THE TOOLKIT CONTAINS:

- **An assessment of how climate change affects cities.**
- **An overview of how urban planning policies can be used to adapt to climate change.**
- **A suite of ten project case studies where climate adaptation was combined with urban planning in C40 member cities.**
- **Tools and resources for a workshop where city planning and adaptation staff can come together and start integrating climate change adaptation into urban planning policies.**

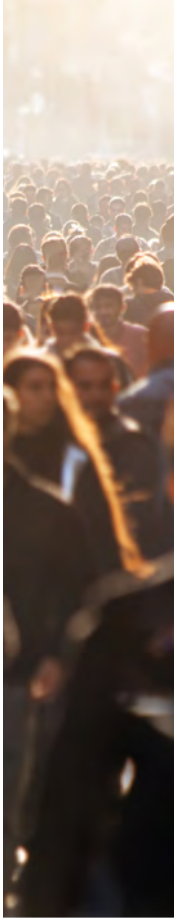
Most urban planners do not need convincing to include climate adaptation thinking into their planning work; indeed many planners actively champion adaptation within their department and beyond. But often, planners need to build a case for including adaptation measures when presenting their projects and engaging decision-makers and other stakeholders. It is hoped that the first two parts of this toolkit will provide planners with the resources to make this case, as well as furnishing adaptation practitioners with some ideas and resources for ways that they can engage their urban planning colleagues. The third part imagines what would happen if a city's planners and sustainability department came together, in a physical or virtual space, and explores the spectrum of outcomes that this could achieve – from a simple, bridge-building 'getting-to-know-each-other' session, to several days spent mapping out collaborative projects for the next five years.

CHAPTER I

The impact of climate change on cities

1.1

How is climate change affecting our cities?



Cities are already feeling the impacts of climate-related hazards, such as extreme heat, flooding, drought, sea-level rise, and storms.

According to C40's Climate *Risk Assessment Framework Taxonomy* report,[6] these were the five risks most frequently faced by cities, the consequences of which have been leading to deadly and costly disasters.

Seventy per cent of C40 member cities report they are already experiencing these hazards as the effect of climate change. And as we experience greater effects of climate change, current scenarios are expected to worsen.

C40 published a report titled *The Future We Don't Want* to demonstrate how serious the impacts of climate change would be in different cities. The report studied a future scenario where climate change was left unabated. By considering global projections and examining local impacts for more than 2,500 cities around the world, the report illustrates a severe scenario of climate impacts, as summarized by Table 1.

Table 1. Estimated number of people and cities impacted by climate vulnerabilities

VULNERABILITY	TIME PERIOD	POPULATION EST.	CITY ESTIMATE
EXTREME HEAT	Present Day	Over 200 million people	Over 350 cities
	2050s	Over 1.6 billion people	Over 970 cities
EXTREME HEAT & POVERTY	Present Day	Over 26 million people	Over 230 cities
	2050s	Over 215 million people	Over 490 cities
WATER AVAILABILITY	2050s	Over 650 million people	Over 500 cities
FOOD SECURITY	2050s	Over 2.5 billion people	Over 1.600 cities
SEA LEVEL RISE	2050s	Over 800 million people	Over 570 cities
SEA LEVEL RISE & POWER PLANTS	2050s	Over 450 million people	Over 230 cities

Source: C40 Cities (2018) The Future We Don't Want, p. 6.
Available from: www.c40.org/other/the-future-we-don-t-want-homepage.

1.2

Mapping out the risks

To understand the magnitude, frequency, and severity of the risks that your city currently faces, and how these will intensify in future scenarios, C40 recommends developing a Climate Change Risk Assessment.

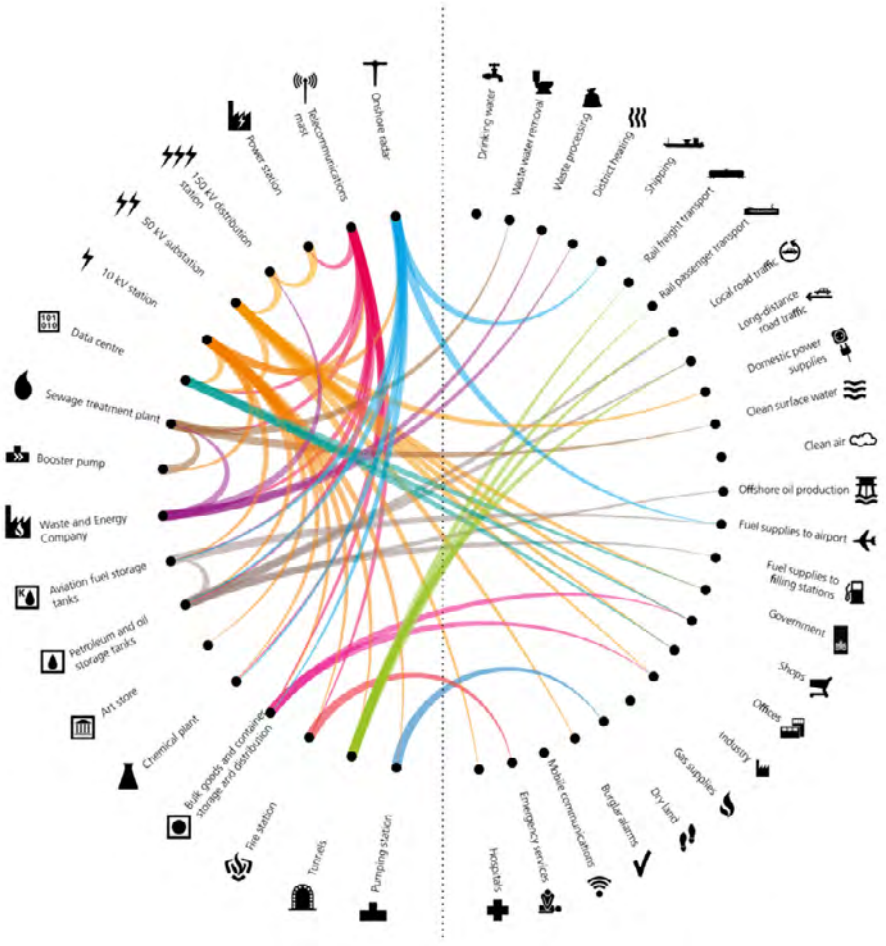
C40 has developed a Climate Change Risk Assessment Guidance[7] to support cities in this process, which identifies three main steps:

1	**Developing future climate projections at a local scale**
2	**Mapping out vulnerable populations, assets, and infrastructure**
3	**Determining the city's adaptation capacity**

The outcomes of this diagnostic should guide the city's adaptation actions, which would prioritize the most vulnerable areas.

An interdependencies analysis, such as the example shown in Figure 1, can help make the Climate Change Risk Assessment more robust. This analysis examines the interconnections among the infrastructure systems of the city, identifying interdependencies spatially as well as operationally, and can help cities avoid cascading failures. C40 has produced the *Infrastructure Interdependencies + Climate Risks* report to support cities in this process.[8]

Figure 1. Example of mapped infrastructure interdependencies in the Westpoort Harbour district



Source: C40 Cities (2017) Infrastructure Interdependencies + Climate Risks Report, p. A-7. Available from: www.c40knowledgehub.org/s/article/C40-Infrastructure-Interdependencies-and-Climate-Risks-report?language=en_US

You can read more on how to address infrastructure interdependencies when adapting to climate change here:

1.3

How can we adapt to climate risks in cities?

To adapt to the impacts of climate change, cities must have a pragmatic approach that involves minimizing damage and reducing vulnerability for both current and future climate risks.

This section delves into different climate risks, describing the impacts of, the importance of mapping the city's vulnerability to, and the various strategies cities have developed to adapt to, each individual hazard.

The Intergovernmental Panel on Climate Change (IPCC) defines *climate change adaptation* as 'adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities'.

1.3.1

Adapting to urban flooding

Ninety-one per cent of C40 cities report being currently impacted by floods.

Historically, the development of cities has increased urban flood vulnerability. As cities grow, buildings and streets take over vegetated, permeable areas in local water basins. Covering permeable surfaces with concrete and other impermeable materials provokes an increase in the rain flow rate, which causes floods to intensify. Another factor that increases the magnitude of urban floods is urban development occurring on riverine flood plains and other low-lying areas. The reduction of space for water bodies and waterways in urban areas is the main driver of flood vulnerability.

Floods can have severe impacts on cities, such as tree loss, infrastructure damage, landslides, loss of economic activity, and increases in vector-borne diseases.

To adapt to floods, cities first need to map their vulnerability to this risk. There are different ways of mapping flood-prone areas. A simple map can be produced by georeferencing residents' emergency calls during a critical flood event. A more complex map can combine information about land elevation and permeability (some of this information can be found in land-use plans), in order to develop a hydrodynamic assessment. This assessment will indicate the direction and intensity of the water flow. A computer-modelled analysis of the flow and infiltration of water in urban areas can provide a more thorough hydrological model of the city. To complete the flood vulnerability analysis, cities can overlay a map of flood-prone areas with one of socio-economic indicators (such as the number of low-income households) or the city's critical infrastructure.

But of course, cities can do more than simply map their vulnerabilities to floods: they can adapt. Existing waterways such as rivers and swamps are often constrained as a city is built up, and this can worsen flooding events when they happen. The main principle when adapting to floods is therefore to acknowledge and recover the city's natural waterways and bodies of water. Increasing natural water infiltration into the ground, allowing it to be retained in some places, and evaporated naturally across different riverine and lake environments, will all help decrease waterflow during a critical event.

Parks are often good places to accommodate water, as they are usable during sunny days and can retain water through heavy rains, but cities can also get creative using different solutions such as permeable paving, underground water retention, and so on. Green infrastructures such as bioswales (channels containing vegetation to slow water infiltration and filter out pollutants from rainwater runoff), rain gardens, and green walls are also efficient strategies to increase permeability and decrease the water flow rate during a critical event.

Urban planners have a crucial role to play in flood adaptation. The city's comprehensive plan, for example, can indicate in which areas water is to be retained and absorbed, and district scale plans can ensure that new buildings and urban infrastructure are flood resilient.

Case study 1

Copenhagen Cloudburst

Copenhagen's Cloudburst Management Plan was a strategy detailing the methods, priorities, and measures related to adaptation to extreme rainfall, following cloudburst events in July 2011. It is a combined solution of surface- and sewer-based strategies that create spaces to store and distribute excessive water from cloudbursts. **You can read the full Copenhagen Cloudburst case study on page 40.**

1.3.2

Adapting to heat

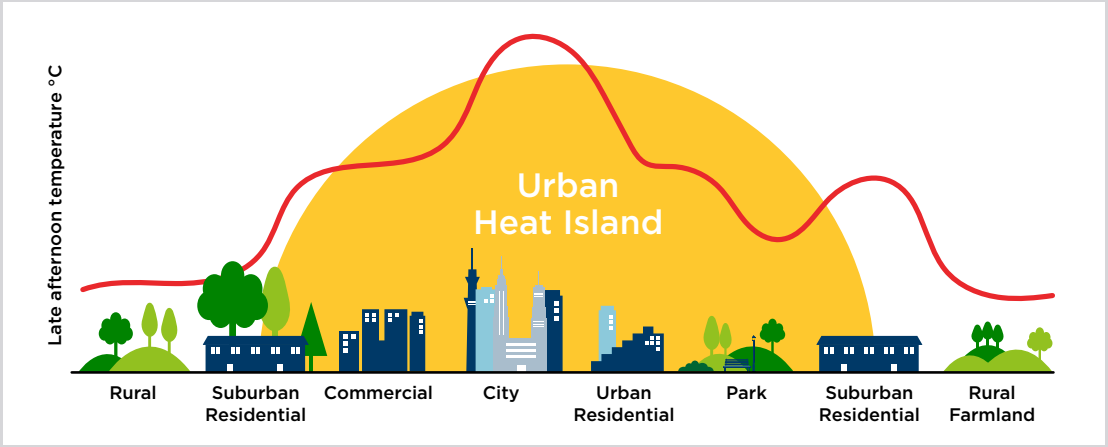
Ninety-two per cent of C40 cities report being impacted by heat waves and an increase in the urban heat island effect.

A dense urban layout and a high percentage of materials with a low rate of albedo (the proportion of light or radiation that is reflected by a surface) are the main causes of the heat island effect in cities. As a city grows, green areas, or otherwise open spaces, are often covered by paving or other non-porous materials, therefore increasing the city's heat vulnerability. A high per centage of asphalt and concrete is typically an indicator of higher heat vulnerability.

Urban heat islands

Heat islands form as vegetation is replaced by asphalt and concrete for roads, buildings, and other structures. These surfaces absorb – rather than reflect – the sun's heat, causing surface temperatures and overall ambient temperatures to rise.

Tall buildings and narrow streets can cause hot air to become trapped between them and reduce air flow. Waste heat from vehicles, factories, and air conditioners may add warmth to their surroundings, further exacerbating the heat island effect.



Fuladlu, K. et al. (2018) The effect of rapid urbanization on the physical modification of urban area. Available from: www.researchgate.net/figure/The-effect-of-Urban-Heat-Island-UHI_fig1_326316773

Extreme heat can impact the health of residents, cause wildfires, overload the electrical system, damage infrastructure, worsen air quality, and much more besides.

To map urban heat, cities can analyse local temperatures (using thermal gauges) or surface temperature using satellite images or flyovers (lidar). In order to determine what areas of the city are most vulnerable to heat, the heat map can then be overlaid on a map of socio-economic indicators, such as the number of low-income households, children, or elderly residents, or access to green space. Figure 2 shows Barcelona's Heat Vulnerability Index for the 2015 heat wave.

To mitigate heat impacts, city officials can ensure that green areas are present throughout the city, consulting the spatial heat map to determine where cooling measures – such as urban reforestation, green roofs, cool roofs, and water fountains – are most needed. Public policies can also guide new developments to include heat mitigation features, for example by requiring the inclusion of cool pavements or roofs – with lighter surfaces to reflect sunlight away – and by restricting the use of asphalt and hard pavements with low albedo factors.

Other urban design features can help reduce temperatures in cities:

Sky-view factor

This is calculated as the fraction of the sky visible from the ground up. Skyscrapers located on either side of a narrow street will lower the sky-view factor and will reflect the sun into the urban area, contributing to the urban heat island effect. Establishing design guidelines that preserve the sky-view factor can decrease the city's vulnerability to heat.

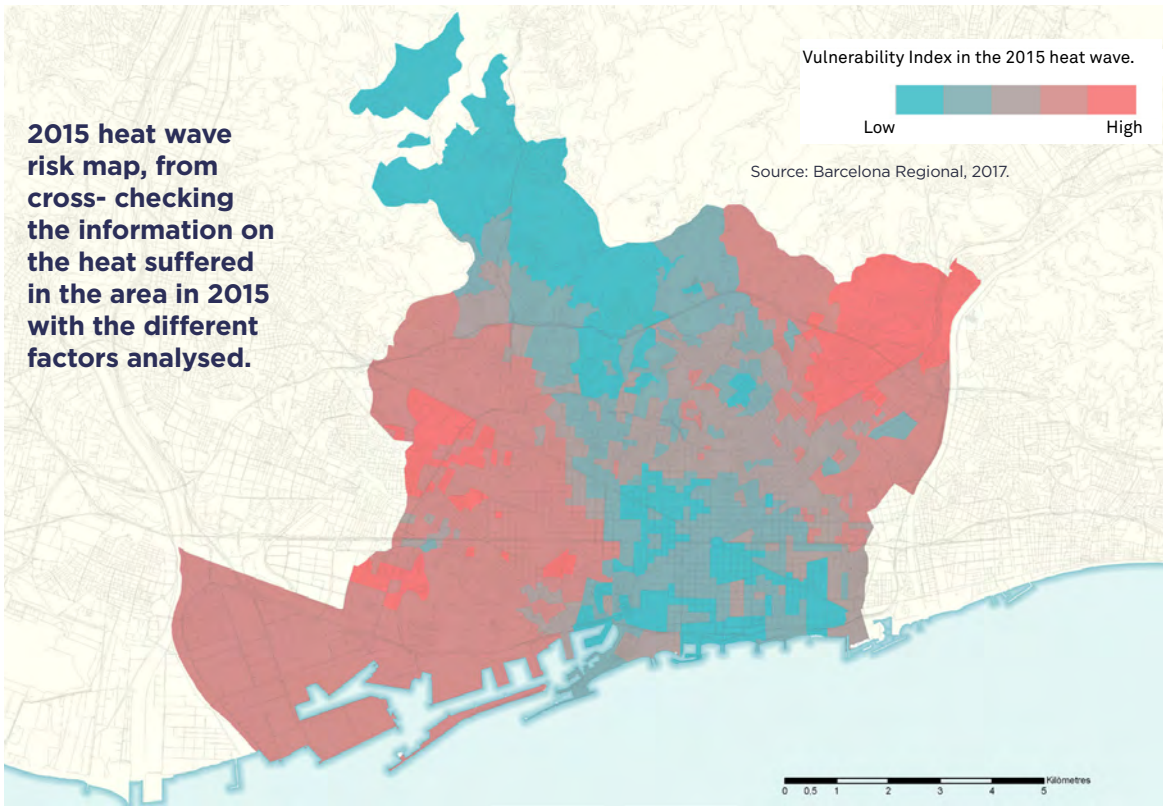
Shading

Shading from buildings and trees reduces the amount of radiation received by other buildings, pavements, and people, thus reducing heat vulnerability. This should always be taken into account in urban design.

Airflow

Designing street grids with wind circulation in mind can increase evaporation, therefore lowering ambient air temperature. Furthermore, green areas can provide a cool airflow and increase evaporation.

Figure 2. Barcelona's Heat Vulnerability Index for the 2015 heatwave



1.3.3

Adapting to drought

Sixty-four per cent of C40 cities report being impacted by droughts.

Drought is a severe risk related to reduced water availability, often compounded by heat and wildfires. Cities located in arid areas are more vulnerable to this risk. However, because of the impacts of climate change, we can now observe the impact of droughts in non-arid cities as well.

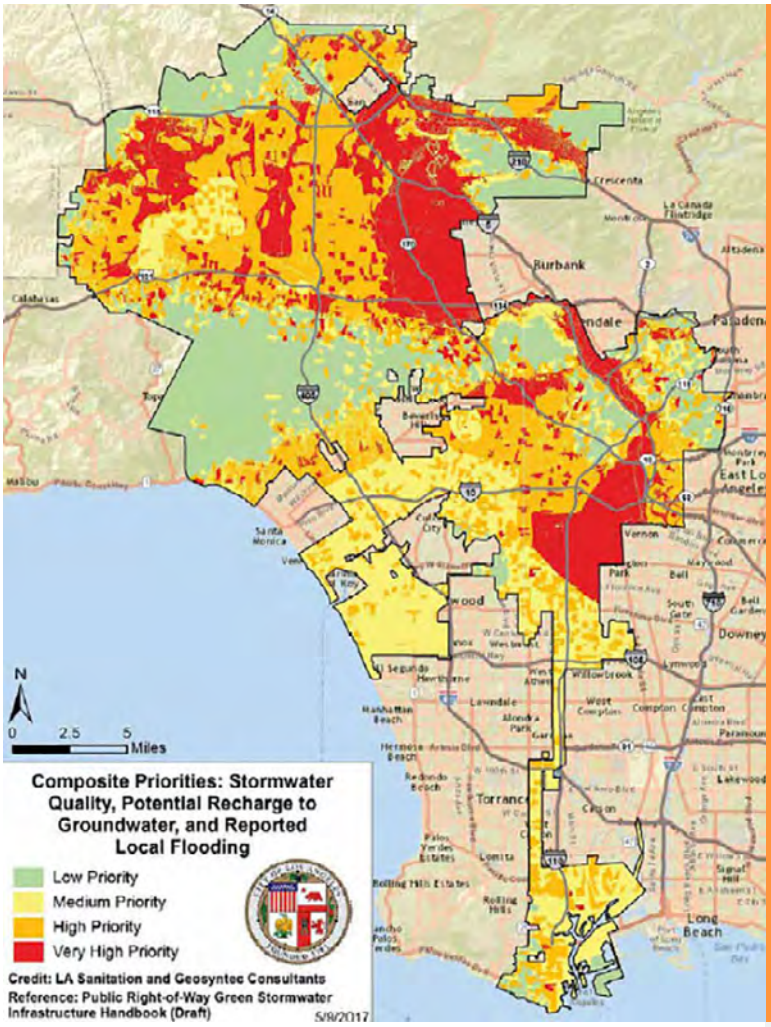
Droughts can have devastating effects on cities, causing wildfires, water shortages, subsidence, loss of biodiversity, and damage to agricultural land.

Drought adaptation is closely related to water management. Thus, to increase resilience to droughts, a city needs to develop a resilient water system. There are different ways to guarantee the availability of water during a drought, such as the sustainable utilization of groundwater, the recycling of wastewater, and rainwater harvesting.

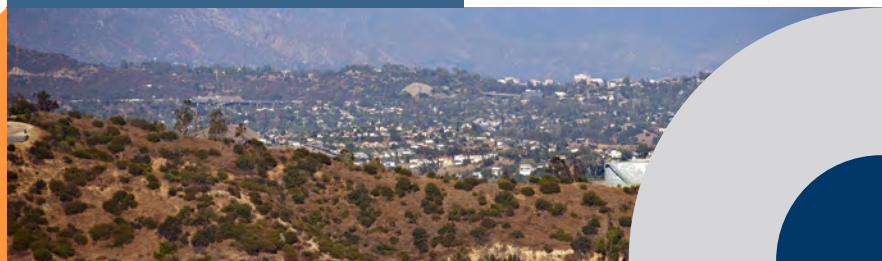
In the medium to long term, boosting a city's urban forest will support water retention. Cites can prioritize native forestation species, which are well-adapted to the local climate and require less water maintenance, to promote groundwater recharge. Another solution commonly used is the desalination of seawater, although this should be carefully considered as it requires a lot of energy, often increasing GHG emissions, in turn intensifying future drought vulnerability. ARUP, working with C40 and other organizations, have published the report *Cities Alive: Rethinking Cities in Arid Environments* which presents a number of solutions for cities to adapt to drought impacts.[10]

As always, mapping is an essential part of the process. To assess the areas affected by drought, cities should map urban green areas and their vulnerability to land fires. A map identifying water retention areas will also help cities prioritize water management actions for dry periods. The map shown in Figure 3, from the City of Los Angeles' Resilient Los Angeles plan, illustrates the city's water management.

Figure 3. Water management priority map of Los Angeles



Source: City of Los Angeles (2018) Resilient Los Angeles, p. 111. Available from: www.lacity.org/sites/g/files/wph1101/f/ED%2022%20-%20Resilient%20Los%20Angeles.pdf



1.3.4

Adapting to sea-level rise

Fifty per cent of C40 cities report having at-risk areas impacted by rising sea levels.

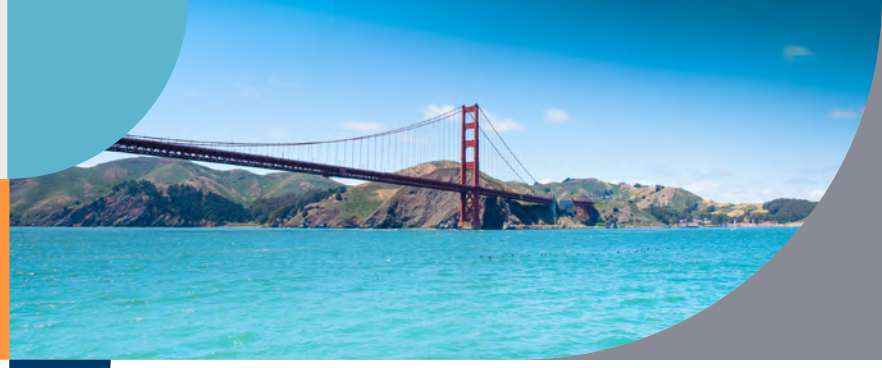
Future projections predict that sea level will rise between one and two meters in different global regions. Coastal cities with areas only a few meters above sea level will be vulnerable to floods, and these low-lying areas must be thoroughly considered in urban plans to avoid serious damages in the near future.

Sea level rise has slow but unrelenting impacts, such as infrastructure damage and loss of economic activity, and can lead to residents needing to move permanently away from vulnerable areas.

To map urban vulnerability to rising sea level, urban planners should assess the city's land elevation, highlighting low-lying areas and considering them in conjunction with climate change scenarios predicting sea-level rise. San Francisco, as shown in Figure 4, mapped how sea-level rise will affect the city in a scenario where no measures were taken to stop climate change.

Figure 4. Map of San Francisco's sea-level rise vulnerability zone

San Francisco Planning (2018) Sea Level Rise Adaptation: Vulnerability Zone (web page). Available from: https://sfplanning.org/sea-level-rise-action-plan#vulnerability-zone. [11]



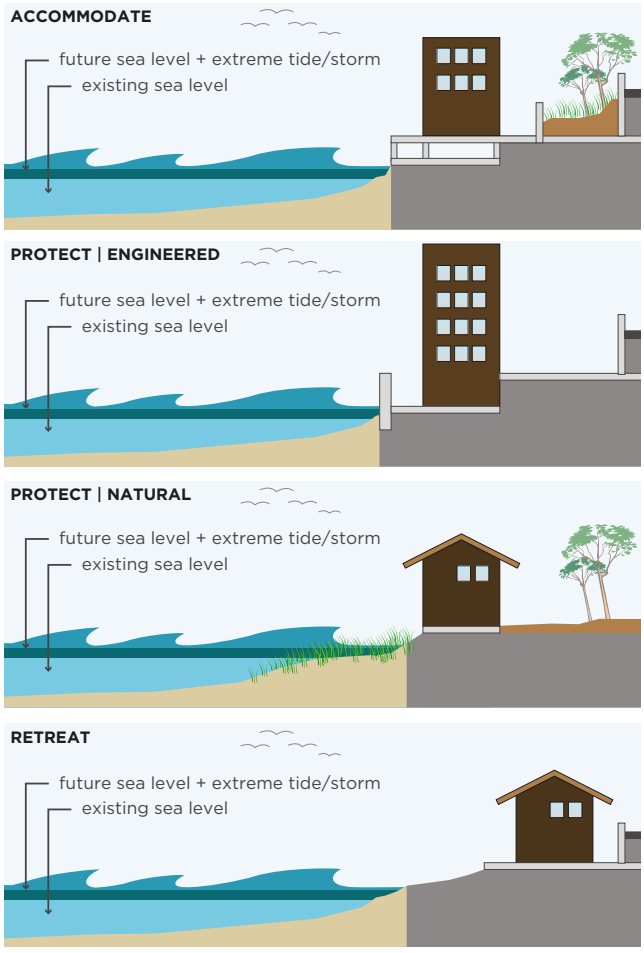
Sea level rise is not a current risk for most cities; however, it will be a high risk in the future. Since its major impacts will occur over the next few decades, cities can plan for it in advance. There are three main approaches to sea-level-rise adaptation: *protect, accommodate, and retreat*. The protect approach has typically been the first response, using hard (grey, or engineered) infrastructure such as bulkheads, dikes, pumping systems, seawalls, and other barriers. This approach can also rely on soft (green, or natural) infrastructure by recovering and increasing the coastal vegetation, protecting coral reefs and coastal tree lines, and generally using the coast as a natural system to buffer coastal communities from inundation – working with nature rather than against it. The accommodate approach focuses on the retrofit of buildings and infrastructure to adapt to rising sea levels. Lastly, for areas that have intense risk exposure, retreat could be the only possible solution. Figure 5 illustrates these approaches as depicted in San Francisco's Sea Level Rise Action Plan.

Regulating development and changing zoning is an often controversial but an increasingly necessary approach to adapting to rising sea levels. Calculating the cost-effectiveness of each approach is a necessary step to select which one, or what combination of approaches, to adopt in a given area.

To avoid creating more vulnerable urban neighbourhoods, a city's land use plan or zoning code should restrict construction in areas exposed to this risk, or at least require for new buildings to be highly resilient to floods.

Figure 5. Intervention options for sea level rise in San Francisco

INTERVENTION OPTIONS



Source: City and County of San Francisco (2018) Sea Level Rise Action Plan, p. 3.2. Available from: https://default.sfplanning.org/plans-and-programs/planning-for-the-city/sea-level-rise/160309_SLRAP_Final_ED.pdf.

Case study 2

Vancouver coastal flood risk assessment program

The City of Vancouver commissioned the Coastal Flood Risk Assessment Program to understand which areas were most at risk, identify knowledge gaps on hazards, vulnerabilities, and coping capacities, and develop a framework with adaptation actions. **You can read the full Vancouver coastal flood risk assessment case study on page 43.**

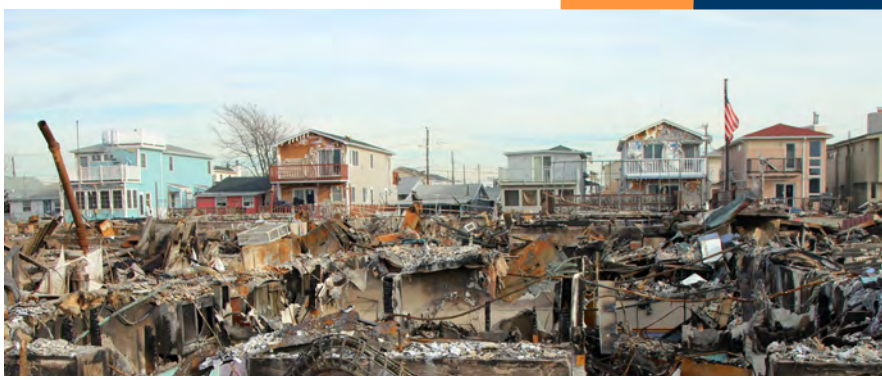
Case study 3

Cape Town: Coastal Management Line

While Cape Town's coastline is one of the city's most important assets, it is also a source of climate risk with rising sea levels and frequent storms. Cape Town's coastal set-back line ensures that development does not encroach on the immediate coastal environment, encouraging risk-averse coastal planning that takes into account climatic changes now and in the future. **You can read the full Cape Town: Coastal set-back lines case study on page 46.**

1.3.5

Adapting to storms



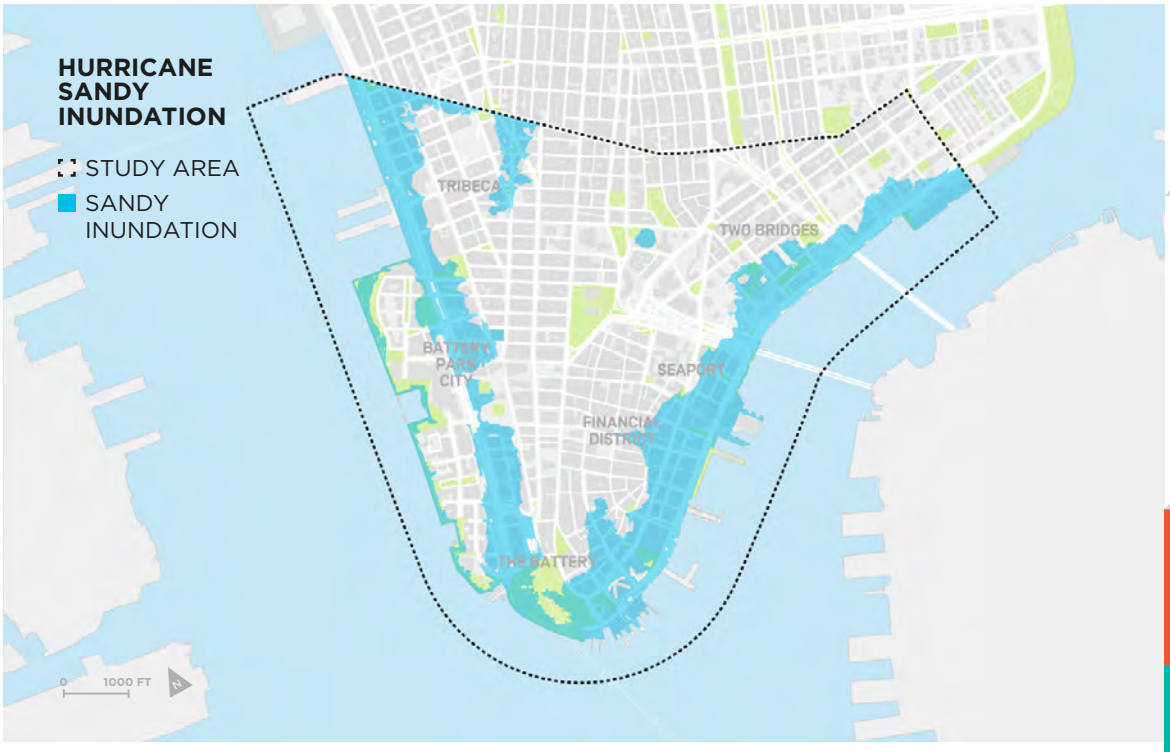
Seventy-seven per cent of C40 cities report being impacted by storms. Storms can entail extreme rain, severe wind, severe hail, monsoons, heavy snow, tornadoes, and hurricanes.

Heavy storms have swift impacts with lasting consequences that can expose a city's vulnerabilities. Storms can cause tree loss, infrastructure damage, population displacement, and energy and water shortages.

To increase storm resiliency, a city can utilize urban designs and grid patterns that might be more resilient to extreme events by decreasing wind power or other storm effects. In addition, policies to reinforce critical infrastructure and develop emergency evacuation plans, along with early alert systems, might minimize the impacts of storms. As a first step, mapping vulnerabilities is key, and learning from the impacts of past events is a good strategy to plan for a more resilient city. New York, for example, mapped the main impacts caused by Hurricane Sandy in 2012, as illustrated in Figure 6.

Like with sea-level rise, the principles of protect, accommodate and retreat also apply to adapting for storms. Besides emergency operations, other adaptation mechanisms include hardening infrastructure (making it more resilient to shocks), adapting building and zoning codes, and strengthening critical and community facilities such as power plants, hospitals, or key access roads and bridges.

Figure 6. Inundation levels from Hurricane Sandy in New York City



Source: NYC Mayor's Office of Recovery and Resiliency (2019) Lower Manhattan Climate Resilience Study, p. 12. Available from: https://edc.nyc/sites/default/files/filemanager/Projects/LMCR/Final_Image/Lower_Manhattan_Climate_Resilience_March_2019.pdf.

1.3.6

Adapting to wildfires

Urban wildfires are not just an effect of droughts and higher global temperatures.They are also exacerbated by sprawling development that displaces and divides native vegetation.

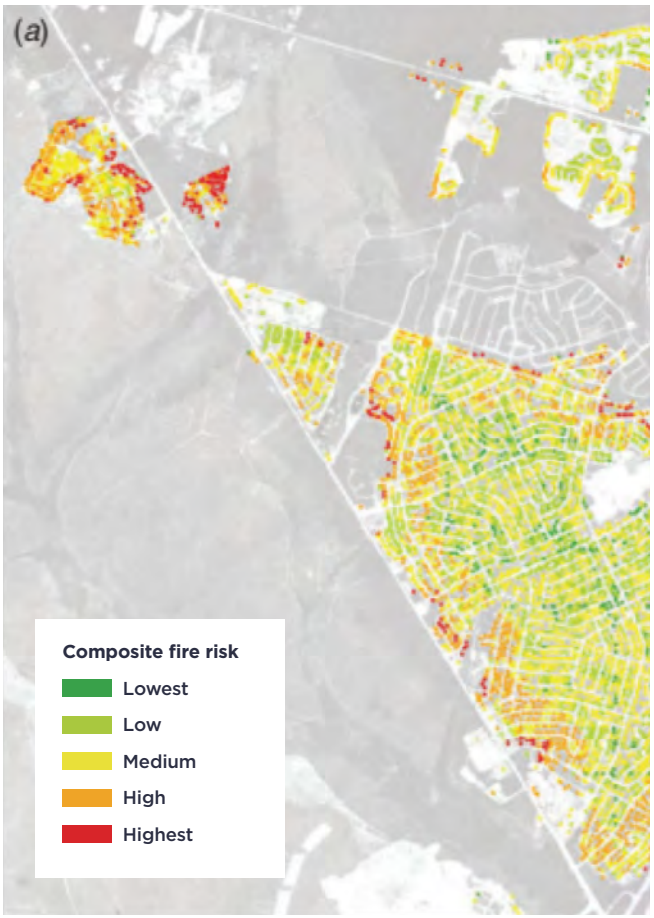
More intense and frequent wildfires are especially dangerous for sprawling cities, where much of the built environment neighbours undeveloped land. Wildland–urban interface refers to the areas of cities where wide open space meets urban, typically less-compact, buildings and infrastructure. Figure 7 shows a map of fire risk along a clear wildland–urban interface.

The position and arrangement of homes and roads within the wildland–urban interface can do much to prevent sparking wildfires and thus experiencing their impact. Like with all adaptation measures, planning for resilience begins with empirical mapping. In the case of wildfires, the focus should be density and siting around fringe areas to identify the most at risk. Property lost due to wildfires tends to be located in low-density residential clusters further away from the city centre. These communities are often far from firefighting resources.

Encouraging denser neighbourhoods (i.e. with less space between individual homes) in cities' peripheral fire zones on the wildland–urban interface boosts a city's overall resilience to wildfires. It is also easier and less costly to provide fire services to denser neighbourhoods. Cities need to overlap and align their comprehensive fire management plans with their land use plans to incentivize infill development in highly exposed areas that are currently low density.[12]

In the wake of disastrous and recurring wildfires, planners in cities like Los Angeles and Melbourne are grappling with how to make existing development in fire zones more secure, identify areas too hazardous to rebuild, and prevent subdivisions from expanding into high-fire-risk areas.

Figure 7. Composite fire risks along wildland–urban interface



Source: Skowronski, N. S., et al. (2016) 'Structure-level fuel load assessment in the wildland–urban interface: a fusion of airborne laser scanning and spectral remote-sensing methodologies' International Journal of Wildland Fire 25: 547–557, at p. 555.

CHAPTER 2

Using urban planning policies to adapt to climate change

2.1

Opportunities to boost resilience

Urban planning, as a technical and political process, is wide in scope, as it regulates the built environment and the use of land, urban infrastructure, green, and public space.

For cities to weather the long-term effects of climate change and continue to thrive, local officials must strive to integrate adaptation principles into urban planning policies, effectively hard-wiring resilience into the city's regulatory tools.

The opportunity is tremendous because cities typically have a very high level of control over their urban planning processes. Local policymakers can use the map of the city's climate-change-related hazards (risk map) to shape urban planning policies that are risk-appropriate. This ensures that urban development is resilient from the onset, avoiding costly adaptation retrofits later on.

Urban planning tools take multiple forms and serve a number of (sometimes competing) objectives, such as: enabling the provision of housing, commercial spaces, or green areas; promoting public safety, economic development, or efficient transportation; and mitigating the city's climate impact.

It is helpful to conceptualize the different potential interactions between planning and adaptation policies in order to understand how to integrate them. To this end, C40 created the Adaptation and Mitigation Interaction Assessment (AMIA) Tool to help cities identify the potential synergies or conflicts arising from the integration of mitigation and adaptation actions.[13] Several of the policies examined involve urban planning, making this a helpful tool for urban planners wanting to explore adaptation options. The tool analyses a range of policies for potential mitigation and adaptation synergies and trade-offs, as well as potential mal-investment risks and piggybacking opportunities.

You can consult the Adaptation and Mitigation Interaction Assesment (AMIA) Tool here

Some key concepts

MAL-INVESTMENT

When an urban planning policy that fails to take into account climate adaptation ends up suffering a climate-related hazard that defeats the primary purpose of the policy.

TRADE-OFFS

Some urban planning measures will increase a city's climate risk, and some climate adaptation policies may have adverse effects on policy priorities set by the city's urban planning strategy. In some cases, those trade-offs are acceptable in order to meet the prioritized policy objective; in all cases, identifying trade-offs can optimize decision-making.

PIGGYBACKING

Often, integrating an adaptation requirement or measure into an urban planning policy can be done at little to no cost. Furthermore, when a policy that primarily has an adaptation goal is implemented, a range of other policy objectives that the city wants to promote can 'piggyback' on the primary policy and bring co-benefits.

WIN-WIN MEASURES

A step further than piggybacking, win-win measures fulfil both local policy priorities and climate adaptation objectives, maximizing the effect across the board.

2.2

Maximizing synergies at every scale

This section will highlight the synergies (positive, reinforcing interactions) between adaptation and urban planning at different scales. It does this by looking at the various urban-planning vehicles that represent opportunities through which climate objectives can be met.

2.2.1

Comprehensive plans

Comprehensive, or strategic, planning refers to the long-term vision or goal that guides local policy on a range of topics such as urban development, transportation, housing, economic development, social inclusion, and the environment.

The comprehensive plan ensures that policies designed in these different areas all support the overarching goals the city aims to achieve. It also ensures that all areas of urban policy work together, so that no contradictions arise.

For a city to be resilient to climate change, it should integrate adaptation principles at the comprehensive plan level, as this ensures that all policies that derive from the plan will promote adaptation. To do this, it is necessary to identify the climate-change-related hazards that the city is vulnerable to and ensure that each area of local policy considers them.

Washington, D.C., for example, is in the process of updating its comprehensive plan. A guiding principle is the integration of resilience into the plan's 'framework' section, which provides the foundation for all of the sections of the plan. Figure 8 shows the four foundational themes upon which the updated comprehensive plan is being built.

Figure 8. Foundational themes for Washington, D.C.'s comprehensive plan

Source: Washington, D.C. (2019) Draft Comprehensive Plan Update. Available from: https://plandc.dc.gov/sites/default/files/dc/sites/Comprehensiveplan/page_content/attachments/2019.11.12%20Major%20Themes.pdf

(Last accessed 1 July 2020).

2.2.2

District-scale plans

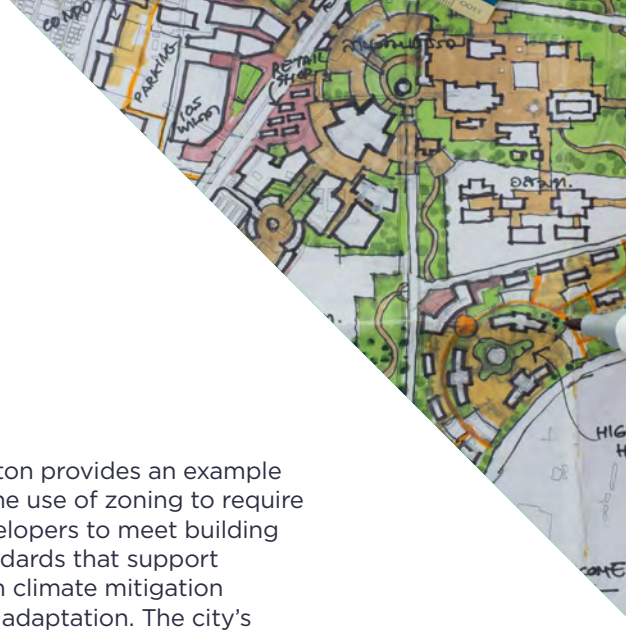
District-scale plans guide the development of a sub-area of the city.

The policies included in this type of plan usually relate to implementation, tailoring the citywide urban strategy to the district level. At this scale, particularly when large amounts of development are planned, local government can pilot more innovative adaptation and mitigation requirements which, once proven successful, can be expanded to the rest of the city.

Case study 4

Vancouver Northeast False Creek

Northeast False Creek is Downtown Vancouver's last remaining piece of large undeveloped land, with 58 hectares, and is vulnerable to flooding from sea-level rise and storm surges. In November 2017, after gathering community feedback, the city created the Northeast False Creek Adaptation Plan, a land-use plan that both supports the redevelopment of the area through rezoning and makes it resilient to flooding. Measures included: raising the required building elevation of ground floors from 3.5m to 4.8m, an enhanced seawall design, the integration of a 'ribbon' of flood management infrastructure (seawalls), and the naturalization of the shoreline (i.e. creating a soft edge with the water through permeable design and vegetation). **You can read about the project in the Vancouver Northeast False Creek case study on page 49.**



2.2.3

Zoning

The city zoning code contains a higher level of detail than comprehensive plans and district plans.

Zoning is the legal backbone of land-use planning and the most powerful tool to regulate the form of a city and the use of its buildings. It is typically applied citywide. This tool defines what is permissible in a given area and varies according to neighbourhood conditions. Zoning can, among other things, determine the height and bulk of a building, how far from the curb it sits, and whether it is used for residential, commercial, or institutional purposes. Since any new building must comply with the zoning regulation in place in the area where it is built, designing a zoning code that integrates adaptation principles at its core ensures that as the city develops and renews its building stock, it grows more resilient.

Zoning plays an essential role for both mitigation and adaptation. Take a low-lying, undeveloped urban area, with some parts prone to flooding. A city's zoning regulation can determine the mitigation and adaptation qualities of the development that will occur there. It could, for example, allow for the development of low-density single-family homes without flood protection design standards. This type of development would both result in higher emissions per capita than denser residential types (because of the reliance on driving associated with sprawling settlements) and make residents vulnerable to floods. Conversely, the zoning law could prohibit development in high-risk portions of the urban area, and mandate flood-resistant, denser development in parts of the area that can be served by transit. These zoning choices, made with the knowledge of the city's climate risks, would result in an optimal outcome from a climate change mitigation and an adaptation standpoint.

Mitigation and adaptation

Mitigation is the action of reducing the emission of greenhouse gases, ultimately slowing down or stopping the warming of the planet.

Adaptation is the action of adapting to existing and expected impacts of climate change, for example higher temperatures, heavier rainfall, more frequent droughts, etc.

Both mitigation and adaptation actions need to be taken concurrently.

Boston provides an example of the use of zoning to require developers to meet building standards that support both climate mitigation and adaptation. The city's zoning code requires, in its Article 37, that all projects achieve at minimum the 'certifiable' level, utilizing the most appropriate US Green Building Council Leadership in Environmental and Energy Design rating system(s). These rating systems integrate both energy efficiency and climate adaptation requirements. Projects also have to follow the city's resiliency policy, requiring developers to complete a resiliency checklist to consider the potential impacts of climate change and how these can be mitigated.

In 2016, the City of São Paulo adopted a new and innovative zoning tool: the environmental quota. With this tool, new developments must meet minimum vegetation lot coverage and soil drainage requirements that are specific to its location. Fiscal incentives are also in place to encourage developers to exceed these requirements. This fine-tuned land-use tool helps the city adapt to climate change by addressing the risks of the urban heat island effect, floods, and droughts, while preserving urban biodiversity.

Case study 5

Washington GAR

Since 2013, Washington, D.C. has had a zoning regulation in place called the Green Area Ratio (GAR). The GAR requires the integration of sustainable landscape elements into site design to reduce the urban heat island effect and help manage stormwater. It presents a menu of options that allows developers to meet guidelines in a number of different ways. **You can read the full Washington GAR case study on page 51.**

2.2.4

Incentive programmes

While zoning mandates and prohibits specific urban forms and uses, incentive programmes rely on tax advantages or other benefits (e.g. a density bonus) to encourage specific urban planning outcomes.

Cities choose to develop incentive programmes to promote a desirable practice that is expensive or uncommon for developers, property owners, or tenants. It can be an excellent way to pilot a climate change adaptation measure.

The City of Toronto launched the Eco-Roof Incentive Program in 2009 to support the uptake of eco-roofs by building owners, make buildings more sustainable, and promote the creation of green jobs. The Eco-Roof Incentive Program provides grant funding for building owners to install new roofing materials – green roofs with living plants and cool roofs that reflect solar heat. These provide environmental benefits and build resilience by significantly reducing the storm water run-off entering Toronto's sewer systems after extreme rain events. As of January 2014, the programme had supported 112 projects totalling 233,000 square metres of roof, reducing energy consumption by an estimated 565 MWh, avoiding 106 tonnes of greenhouse gases, and diverting 8.7 million litres of storm water annually from the sewers.

Case study 6

London Greening the Business Improvement Districts (BID)

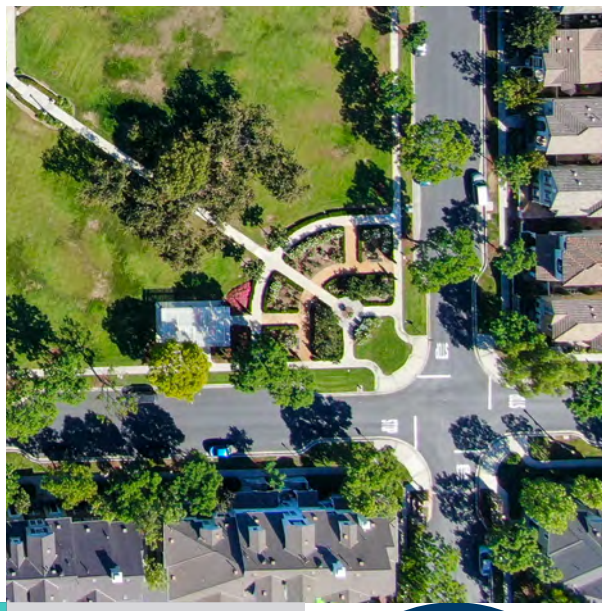
London's Greening the Business Improvement Districts (BID) initiative, while not an incentive programme per se, is similar in that it relied on the involvement of the private sector to deliver sustainable outcomes, with public guidance. Public and private sector worked together to help identify opportunities to increase green cover. You can read the full London BID case study on page 54.

2.2.5

Urban design guidelines

Urban design guidelines concern the physical character of the city's buildings, streets, and public space.

They can be applied citywide, included in a neighbourhood plan, or in a zoning area. Because urban design guidelines determine the characteristics of outward-facing private or public space they can carry great adaptation benefits when properly crafted.



Case study 6

New York building guidelines for climate resilience

New York City faces a high risk of flooding especially in extreme weather events, as shown by Hurricane Irene in 2011 and Hurricane Sandy in 2012. As these events are projected to continue happening in the future, the city has developed design guidelines for climate resilience. They address the increasing flood risks of NYC and make it more durable in the face of sea-level rise, extreme precipitation, and extreme heat. The city has iteratively tested and piloted its Climate Resiliency Design Guidelines since 2017, and released several updated the city's versions since.

You can read about New York's guidelines for climate resiliency in the case study on page 57.

2.2.6

Public infrastructure

Public infrastructure serves residents and visitors by performing key functions, such as providing physical access (a bridge or a transit line), energy (the electric grid), water, sewage, or open space.

Urban planning regulation plays a role in the development of public infrastructure and its interactions with the broader urban environment. Integrating adaptation principles when planning for public infrastructure ensures that the infrastructure not only performs its core function, but is in itself resilient and helps the city adapt to climate change.

Case study 8

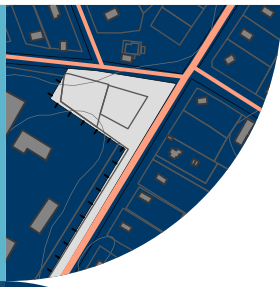
Rotterdam Benthemplein Water Square

Rotterdam is a dense delta city of impermeable surfaces with a substantial need for water storage, in the face of increasing extreme rain events that put pressure on sewage systems and lead to surface flooding and water contamination. The city decided to develop a 'water square' that would serve a double purpose: providing residents with open space and adapting to climate-change-related extreme rain events by storing water. After extensive neighbourhood outreach and a pilot project, Benthemplein Water Square opened in 2013, and is capable of holding 1.7 million litres of water in case of extreme rain. You can read about Rotterdam's water square in the case study on page 60.

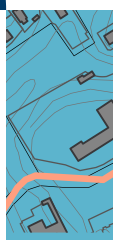
Case study 9

Singapore: Bishan-Ang Mo Kio Park

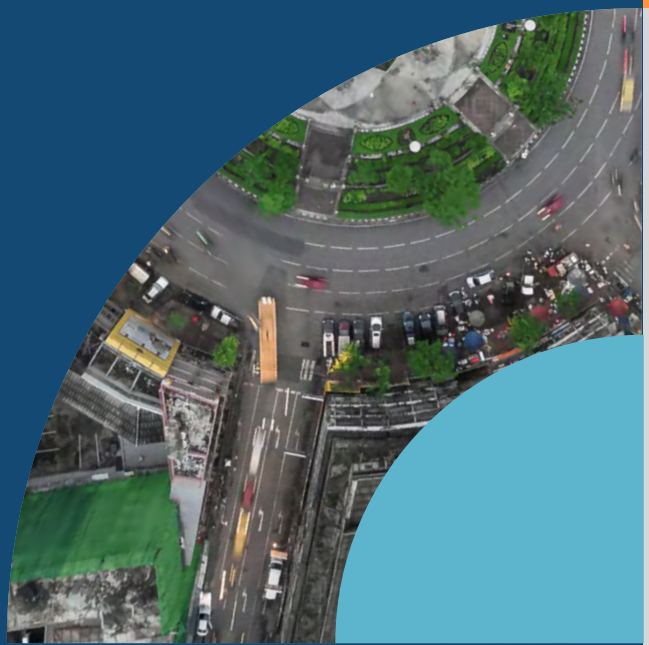
The Kallang River in Singapore runs through Bishan-Ang Mo Kio Park. Previously a concrete canal, it was transformed into a naturalized river that meanders through the park. This project was an innovative drainage improvement that increased the capacity of the waterway (thus reducing flood vulnerability) while providing a green space for the public to enjoy. The full Singapore Kallang River case study can be found on page 63.



CHAPTER 3



Putting it all together: Integrating climate adaptation into urban planning policies



3.1

Where to begin?

As the two previous chapters have shown, adapting to climate change is a necessity for cities, and there are great efficiencies in and opportunities for embedding climate adaptation principles into urban planning policies.

However, in most cities, this does not typically happen, as adaptation professionals and urban planners seldom interact, and have different goals. This can be due to a siloed government structure, the difference in the professionals' background, or the fact that climate adaptation is fairly new as an area of public policy.

Sometimes, there is a top-down effort to integrate adaptation and planning functions, whereby the city council or mayor mandates that any urban planning policy must incorporate climate adaptation principles. However, this process can be politically onerous and time consuming. Far better is when climate adaptation professionals and urban planners within the city government come together organically and take it upon themselves to bridge the gap between the two functions.

In this chapter, we imagine a scenario where city officials from the adaptation and planning sectors take the opportunity to convene, educate each other, and strategize on their collaborations. We have set out some ideas, tools, and resources for a workshop or training session where planners and adaptation specialists can learn about each other's worlds and build on each other's expertise. Where there is enough time and will, this process can move beyond the academic and actually *deliver* real urban planning policies that integrate climate adaptation principles in a meaningful and effective way.

3.2

Running a climate adaptation workshop

The initiative to run a workshop can come from either the urban planning or the adaptation side, but it is essential that the two sectors be brought together during the session in order to achieve real results.

The entire process can be done at low cost, and starting it off is as simple as sending an invitation to colleagues across the two departments and setting aside a space to meet. Remember to bear in mind any social distancing requirements established by the local authorities when planning the workshop space and number of attendees. This framework could be applied equally well in the right virtual space, should face-to-face meeting not be possible.

The rest of this chapter provides ideas, tools, and resources for individuals convening and facilitating a workshop. We look at planning the session, ideas for running the session, and how to harness momentum after the event.

We will focus on:

- ✓ **Planning a workshop**
- ✓ **Choosing the right format**
- ✓ **After the workshop: Harnessing the momentum**

3.2.1

Planning a workshop

Strategy

It is important for participants to define together the workshop's short-, medium-, and long-term goals. Doing this collectively establishes buy-in, keeps conversations outcome-driven, and demonstrates the connection between the topic and the participants' work. Define concrete, measurable objectives, and be sure to clearly assign roles and basic accountability mechanisms.

Some examples of goals might be:

Short-term

- ☑ Get to know everyone participating from different departments, and become familiar with how decisions are taken in each team.
- ☑ Identify issues by overlapping climate risk maps with existing built environment and zoning maps.
- ☑ Identify current projects that need to integrate climate risks and/or urban planning priorities.

Medium-term

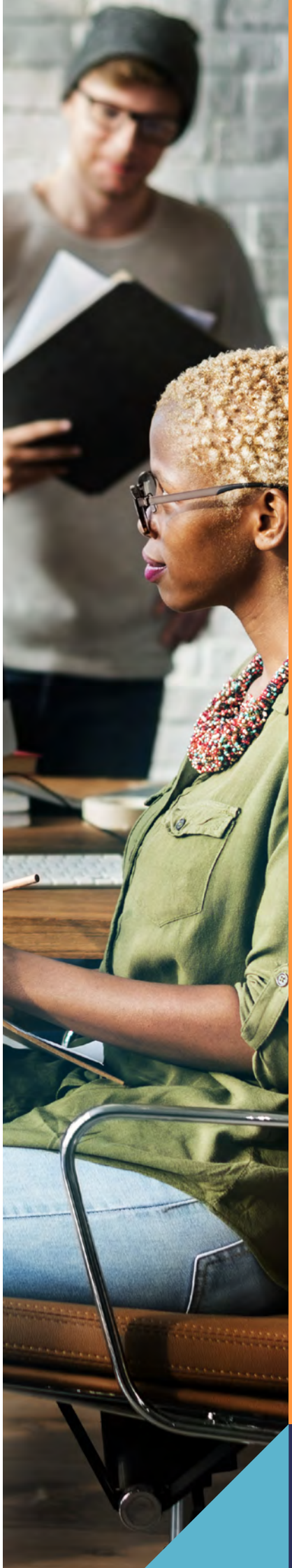
- ☑ Implement changes in policy to address oversights related to the nexus of adaptation and urban planning.
- ☑ Update zoning code to disincentivize new development in areas vulnerable to climate risks.
- ☑ Embed regular collaboration between departments; for instance, creating a cross-departmental committee that meets every quarter.
- ☑ Identify at least one priority project for the next 2–3 years.

Long-term

- ☑ Identify a portfolio of projects to be carried out over the next 3–5 years.

Staff

- **Identify the city departments and agencies** that need to be involved in the process to ensure its success. In some cities, this may be more than two, depending on how the topics of climate resilience and urban planning are distributed, and may involve the Mayor's Office.
- **Obtain buy-in** from senior leadership in relevant departments on conducting this training with their staff.
- **Identify individuals** in each department or agency who will represent their colleagues and motivate them to advance the integration of climate adaptation and urban planning. Choose staff who strongly support the process, have peer credibility, and potentially decision-making power.
- **Think about ways to motivate staff to attend.** For example:
  - Link the content to a current project,
  - Have senior employees encourage attendance, or
  - Make the workshop count towards training requirements.



Preparation

Before the workshop, put together and circulate to attendees:

- [ ] **A list of the main priorities** of the departments and agencies that are involved. You may find that sometimes these priorities do not align. For instance, the resilience agency could want to prohibit development in at-risk areas, while the planning department wants to facilitate development across the board to address the city's housing crisis. It is important to acknowledge those misalignments to produce meaningful interactions. A comparison chart prepared in advance highlighting the misalignments could be helpful to attendees.
- [ ] **Any documents** showing how climate risks affect or will affect the city (particularly maps and other graphic documents as this will help city officials visualize the need for integration).
- [ ] **Key terminology** from the areas of urban planning and climate adaptation, put together by the relevant department staff.
- [ ] **Case studies** from this toolkit that are most relevant to the content that will be dealt with at the training workshop.
- [ ] **Any other materials** that workshop attendees should review towards training requirements.

3.2.1

Choosing the right format

If you have 2–3 hours

Focus on making the case for integrating adaptation and land-use planning, present a few case studies of successful collaboration and allow staff to get to know each other.

Inspire participants to take the lead on collaborating when the opportunity arises. For example, participants from the planning function could commit to contacting a designated adaptation colleague when beginning the regularly scheduled update of a neighbourhood plan, to ensure that climate risks are appropriately addressed from the start of the process.

Example session format:

30 minute overview of the principles of both climate adaptation and urban planning

30 minute overview of case studies (or a few particularly relevant ones)

1-hour staff interaction (e.g. brainstorming activity on integrating their work)

If you have a full day

Follow the previous instructions including the half hour overview and the hour-long staff interaction session, but go into more depth on the case studies.

Include an additional session on the five categories of hazards outlined in Chapter 1 of this toolkit, and how urban planning policies can address them.

Introduce a specific city project where collaboration is possible. Focus on identifying one priority project that can be implemented in the next 2–3 years, with immediately actionable items and opportunities for re-evaluation.

Examples of projects could include:

- Updating the zoning code.
- Updating the comprehensive plan.
- Updating the district/ neighbourhood plans.
- Development of a transit-oriented development strategy.

If you have 2 – 3 days

Follow the previous instructions but encourage participants to think a bit longer term. Include extensive time for *charrettes* to pilot the future collaborative work departments will do.

Identify common projects and gaps between departments, to see if there are overlapping goals.

Identify future urban planning projects that have the best potential to pilot climate adaptation strategies, through a collaboration between departments.

Map out priority projects for the next 3–5 years.

What is a charrette?

The US Environmental Protection Agency defines a charrette as "an intensive, multi-disciplinary workshop with the aim of developing a design or vision for a project or planning activity. Charrettes are often conducted to design such things as parks and buildings, or to plan communities or transportation systems. A team of design experts meets with community groups, developers, and neighbors over a period lasting from one day to a couple of weeks, gathering information on the issues that face the community. Charrette participants then work together to find design solutions that will address the issues that stakeholders have identified as priorities and result in a clear, detailed, realistic vision for future development."[14]

The charrette methodology for public participation can be used to enhance and facilitate the collaborative design of projects that involve multiple departments within the city administration and it is particularly useful for land use planning and adaptation issues that require the analysis of future scenarios. Charrettes can bring main stakeholders in the city administration together to facilitate efficient and participatory decision making. At its core, a charrette is a powerful tool to create partnerships and positive working relationships among people with diverse cultural and technical backgrounds.

If you want to learn more about charrettes, review case studies, and access additional resources you can consult the US National Charrette Institute website: www.canr.msu.edu/nci/.

In all cases

The training workshops that generally achieve the best outcomes are those that are the most dynamic and engaging – not necessarily those that provide the most content.

The classic presentation format can set the scene, explain key land-use planning and climate adaptation principles, and also provide information on major projects and case studies. Other, more dynamic, session formats, however, will ensure information is retained and best encourage collaborative, creative thinking.

Towards the end of the session, always take the time to determine the next steps that will keep the momentum from the workshop going. See the next section of the toolkit for an example list of follow-up actions and a suggested timescale.

Keep in mind the following adult learning principles that will allow you to deliver a successful training workshop:

- Be specific about the goals of the departments/ agencies involved: this ensures that participants feel their organizational priorities are being taken into account, and the workshop is relevant to them.
- Ensure there is plenty of space and time for attendees to share their own relevant knowledge and experience, allowing for different communication preferences: speaking to a larger group, discussing in smaller groups, communicating in writing.
- Capture concrete follow up actions from workshop discussions and assign key staff to advance on those actions and collaborate with each other.

More specifically, here are some tips that relate to climate adaptation and urban planning that can help your workshop meet its goals:

- [ ] Clarify and communicate the aims of both urban planners and adaptation staff; demonstrate the extent to which collaborating with one another can help them achieve those aims by unlocking co-benefits.

- [ ] Demonstrate that integrating climate adaptation principles into urban planning policies is low-cost, efficient, and worthwhile, using as much concrete data and localized climate impact information as you can, in order to obtain buy-in from participants.

- [ ] Facilitate activities that promote trust-building among staff members, as this will be crucial to making collaborations viable: budget plenty of time during sessions for those interdepartmental interactions you are seeking to facilitate outside of the workshop.

- [ ] Present the information in a familiar way that considers the audience's training and background. For example, maps are a particularly good medium for urban planners to digest information, as they are used to working with them.

- [ ] Help workshop participants identify the ways in which urban planning policies are already integrating climate adaptation, and how climate adaptation measures are considering urban planning priorities, so as to make things more concrete and identify opportunities for improvement.

- [ ] Ensure that participants do not only see and hear, but also practise directly some of what they've just learnt: this is essential to retaining information presented during the workshop. To this end, it is vital to identify concrete opportunities to implement what was discussed, so that participants can see in their work, as soon as the following week, what the training has achieved for them.

- [ ] Plan the workshop with an awareness of the potential barriers to prioritizing climate action, and a plan to address them:

  - Adaptation to climate change may not appear a priority if the city hasn't suffered climate-change-related impacts; local climate data and projects are crucial to demonstrating that it is necessary to start planning now.

  - The political context may induce a de-ranking of climate action on the agenda. Identify what levers could be targeted (mayor's office, state/regional level, constituents). Work with public advocacy and academic groups to address those challenges and know that educating city employees is a powerful first step.

3.2.3

After the workshop: Harnessing the momentum

It is crucial to harness the momentum from the workshop and build on the foundations that have been planted. The following suggestions may be helpful, however they may not all be relevant in every case, and there may be other actions needed for individual scenarios. Tailor the follow up actions to your workshop.

The Monday after the workshop:

Send all participants the materials and outputs from the workshop, as well as a list of the follow up actions that were agreed upon.

Within a week of the workshop:

Begin enacting the mechanisms for future collaboration between departments. Schedule standing inter-departmental meetings and change departmental policy to mandate contacting the urban planning department/ adaptation specialists at the inception of a new project.

Confirm points of contacts in various departments and explain to them their next steps while keeping all informed.

Within one month:

Organize lunchtime brownbag presentations where staff can present relevant projects and receive immediate feedback.

Within two months:

Create an interest group made up of staff from various departments who can serve as urban adaptation champions and in some cases subject matter experts.

Within six months and then twice a year:

Release a progress report or newsletter to inform all departments of adaptation-relevant policies or projects.

Within one year:

Reassess the city's climate conditions, hazards and vulnerabilities on an annual basis either among the adaptation interest group or wider departments.

3.3

C40 CITIES

Further assistance

We hope the guidelines presented in this section are helpful pointers to design an effective workshop.

If staff from a C40 member city require more assistance, know that C40 Cities can support you in organizing both virtual and in-person workshops on this topic, depending on available resources. Contact us to explore how we can assist, free of charge, with the development of tailored workshops based on your city's specific needs and objectives.

Notes and sources

1 **United Nations Department of Economic and Social Affairs (2018) '68% of the world population projected to live in urban areas by 2050, says UN'.**
Available from: www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html
(accessed 23 June 2020).

2 **C40 Cities (n.d.) 'Why Cities?'**
Available from: www.c40.org/why_cities
(accessed 23 June 2020).

3 **NASA (2019) 'Video: Global Warming from 1880 to 2019**'.
Available from: https://climate.nasa.gov/climate_resources/139/graphic-global-warming-from-1880-to-2018/
(accessed 23 June 2020).

4 **The Paris Agreement came into effect in 2016, and is an agreement within the United Nations Framework Convention on Climate Change to which 189 states are party. The long-term goal of the Paris Agreement is to limit the increase in average global temperature to 1.5 C.**

5 **C40 Cities (2017) 'Cities are creating a resilient future by adapting to climate change'. C40 Blog.**
Available from: www.c40.org/blog_posts/cities-are-creating-a-resilient-future-by-adapting-to-climate-change
(accessed 23 June 2020).

6 **C40 Cities (n.d.) City Climate Hazard Taxonomy.**
Available from: www.c40.org/researches/city-climate-hazard-taxonomy
(accessed 23 June 2020).

7 **C40 Cities (2018) Climate Change Risk Assessment Guidance.**
Available from: www.c40knowledgehub.org/s/article/Climate-Change-Risk-Assessment-Guidance?language=en_US
(accessed 23 June 2020).

8 **C40 Cities (2017) Infrastructure Interdependencies + Climate Risks.**
Available from: www.c40knowledgehub.org/s/article/C40-Infrastructure-Interdependencies-and-Climate-Risks-report?language=en_US
(accessed 23 June 2020).

9 **UCAR Center for Science Education (2011) 'Urban Heat Islands'.**
Available from: https://scied.ucar.edu/longcontent/urban-heat-islands
(accessed 30 June 2020).

10 **ARUP (2018) Cities Alive: Rethinking Cities in Arid Environments.**
Available from: www.arup.com/perspectives/publications/research/section/cities-alive-cities-in-arid-environments
(accessed 23 June 2020).

11 **See also** https://default.sfplanning.org/plans-and-programs/planning-for-the-city/sea-level-rise/160309_SLRAP_Final_ED.pdf.

12 **Syphard, A. D., et al. (2013) 'Land Use Planning and Wildfire: Development Policies Influence Future Probability of Housing Loss' PLoS One 8 (8): e71708.**
Available from: www.ncbi.nlm.nih.gov/pmc/articles/PMC3743760/
(accessed 30 June 2020).

13 **C40 Cities (2018) Adaptation and Mitigation Interaction Assessment Tool.**
Available from: www.c40knowledgehub.org/s/article/Adaptation-and-Mitigation-Interaction-Assessment-AMIA-tool?language=en_US
(accessed 23 June 2020).

14 **United States Environmental Protection Agency (n.d.) 'Public Participation Guide: Charrettes'.**
Available from: www.epa.gov/international-cooperation/public-participation-guide-charrettes
(accessed 11 July 2020).

Appendix

CASE STUDY 1

Copenhagen: Cloudburst Management Plan

Copenhagen's Cloudburst Management Plan was a strategy detailing the methods, priorities, and measures related to adaptation to extreme rainfall events, following cloudburst events in July 2011. It is a combined solution of surface and sewer-based strategies that create spaces to store and distribute excessive water from cloudbursts.

Project start date:	**August 2011**
Status of project:	**Currently in progress (total estimated time to implement all projects is 20 years)**
Department in charge:	**Copenhagen City Council (Climate Unit) alongside Greater Copenhagen Utilities (HOFOR)**
Departments consulted/outreach:	**Copenhagen Energy, the city of Frederiksberg, and the Frederiksberg Utility Company, since rain that falls on Frederiksberg must pass through Copenhagen to be treated/released**
Projects/groups associated:	**The Climate Change Adaptation Plan, Co-Create Copenhagen, the 2025 Climate Plan**

What is the Cloudburst Management Plan?

Goal: The goal is to achieve a benchmark level of protection – one at which Copenhagen does not suffer damaging floods from a 100-year rainfall event. The overall programme includes 300 projects over the next 20 years, which can be combined with other urban developments. These projects include:

- Storing storm water,
- Draining storm water out to sea, and
- Mitigating floodwaters through green and blue infrastructure.

Cost: The total cost for the combined Cloudburst Management Plan is $1.63 billion USD with investment shared by the municipality ($700 million USD), the utility company ($600 million USD), and taxpayers ($400 million USD).

Urban space improvements are funded by municipal budgets while the costs for the technical solutions (hydraulic functions) are covered by HOFOR.

Hazards addressed: Hydrological – 'cloudburst' is a term for a heavy rainfall event with more than 15 mm of precipitation in 30 minutes. In Copenhagen, increasing rainfall and coastal flooding combine in cloudburst events and can cause major damage in a short amount of time.

Scope: The Cloudburst Management Plan is citywide.

Why was the plan created?

Rationale for project/policy: Following the July 2011 cloudburst that caused damages worth close to €1 billion, Copenhagen decided it needed a better way to manage the water inundating the city during these downpours. After conducting a detailed financial analysis, the combined solutions of a cloudburst management plan proved most cost-effective. The plan uses some traditional methods of draining water away through a network of underground pipes, as well as 300+ surface projects that double up as recreational space when not being used for water storage. Copenhagen wanted to move away from expensive traditional grey infrastructure and serve as a global example of tackling a huge urban problem using green and blue infrastructure such as cloudburst streets and green spaces to absorb rainwater.

Challenges/barriers to be addressed from both a land use and adaptation perspective:

- **Technical Updates:** At first the plan was for the majority of the flood water to be stored in open 'buffer areas' that could double as recreational space when not in use, but this turned out to not be enough storage and the plan has now been updated to include more roads and canals where the water can drain out to the sea.
- **Securing funds:** The City of Copenhagen negotiated with national authorities to change the legislation and allow the cloudburst management project to be paid for with water taxes.
- **Interdepartmental Coordination:** A steering committee including unit managers from the Technical and Environment Department and HOFOR are ensuring that targets are met, and there are additional committees to address other planning questions.

Who was involved in the creation of the plan?

Stakeholders involved: The primary stakeholders were the City of Copenhagen, who produced reports and cost-benefit analyses, and the climate unit of Copenhagen City Council with HOFOR, who developed the plan itself. Since rainwater transcends city boundaries it was also necessary to form a cooperation agreement with the nearby municipalities of Frederiksberg, Gentofte, and Gladsaxe and their utility companies.

Role of political leadership: Cloudbursts have caused such extensive damage in the city that city leadership was immediately in favour of the plan.

How was the plan implemented?

Best practice strategies for implementation:

- **Implementing previously piloted solutions:** There was a pilot project in Skt. Kjelds neighborhood where green surface solutions were installed and proved beneficial during cloudbursts in absorbing excess water and keeping floods from damaging too much. The success of these were later implemented into the plan.
- **Pragmatic approach to risk management:** The infrastructure is not designed to prevent floods entirely but to keep them to a minimally damaging level in the event of a 100-year storm to increase coping capacity.
- **Creative financing:** Maintenance of sewers and traditional forms of storm water management were financed through water taxes, collected by public water companies and managed by the local government. Copenhagen was able to successfully lobby the national government to expand the projects that water taxes could fund to include green and blue infrastructure. This was helped along by the national government prioritizing adaptation more, and the city being able to demonstrate a good business case for the new adaptation solutions and eventually winning over the Ministry of Finance.
- **Detailed cost-benefit analysis:** Having figures relating to the financial implications of the traditional cloudburst management solution, the combined solution, and doing nothing helped to make the case for financing and implementing the plan.
- **Including integrative measures:** One reason the plan was so economically viable was the ability to integrate adaptation measures into existing and planned infrastructure. This made the measures easy to implement as well as having cost savings.

Outcomes and lessons learned

Lessons learned:

- **Cost-benefit analyses** showing that innovative solutions could be financially beneficial were crucial in gaining political backing for the project.
- The **multifunctional** aspect of many of the planned projects is also crucial – there is the possibility to integrate storm water management into **existing urban infrastructure** such as streets and parks.

Results of the project:

Several projects have already been implemented and more are in progress. The net benefit of the cloudburst management plan is $700 million USD with an even greater amount of savings of flood damage costs over the years. There is also a projected savings of $160 million USD from the combined solution and integrating the cloudburst projects with other maintenance and urban projects. An increase in real estate prices of $220 million USD is also projected as a result of the new flood-proof urban spaces, which will lead to high municipal tax revenue.

Co-benefits:

- Economic:
  - Implementing all of the projects will create more than 13,000 jobs.
  - Insurance rates for citizens are expected to go down as flood risks decrease.
- Environmental:
  - Water quality of the harbor will improve if contamination of floodwater is prevented.
  - Greening of city will reduce urban heat island effect.
- Health:
  - Reduced human contact with sewer water as a result of flooding.
  - Increased recreational areas for citizens.
  - More green spaces reduces air pollution.

Vancouver: Coastal Flood Risk Assessment Programme (Phases I-III)

The City of Vancouver commissioned the Coastal Flood Risk Assessment Programme (CFRA) to understand the city's vulnerability to flood hazards caused by coastal storm surge and sea level rise. The city wanted to understand which parts of the city were most at risk and gain an understanding of knowledge gaps on hazards, vulnerabilities, and coping capacities. The latter stages of the programme include developing a draft framework to implement adaptation actions and identify planning tools. The city retained a team of consultants to identify and quantify the people, property, and infrastructure at risk of damage as a result of sea level rise, and to develop policy options that can minimize the hazard, exposure, or vulnerability of residents and property at risk.[1]

Project start date:	**July 2012**
Department in charge:	**City of Vancouver**
Departments consulted/outreach:	**The project included Planning, Engineering, Park Board, the Port of Vancouver, Natural Resources Canadaand more**
Projects/groups associated:	**The project was carried out under Vancouver's Climate Change Adaptation Strategy. The studies were completed by consultants including Northwest Hydraulic Consultants Arlington Group, Ebbwater Consulting, Compass Resource Management and Urban Systems**

Summary

Goal: The overall goal of the programme was to identify the risk from sea level rise and to develop policy options to minimize this risk. The programme was divided into three phases:

- Phase I: Define and understand flood hazard and risks by conducting a robust flood hazard modeling and mapping exercise as well as a vulnerability assessment.
- Phase II: Make draft recommendations for specific adaptation projects in priority areas.
- Phase III: Review results, determine risk tolerance and thresholds, and confirm a timeline for the 11 priority areas.

Cost: The costs for the for CFRA were determined by their phases:

- Phase 1: $430,000 CAD ($342,000 USD) – funding from the Federal/ Provincial Gas Tax Program under the General Strategic Priorities and Innovations Fund, Natural Resources Canada, and City of Vancouver budget.
- For Phase II: $270,000 CAD ($215,000 USD) – from the City of Vancouver budget.
- For Phase III: $84,000 CAD ($67,000 USD) – from the City of Vancouver budget.

Hazards addressed: Hydrological – Vancouver is vulnerable to flooding due to sea level rise and storm surges.

Scope: Citywide – focused on the flood hazard zones located in the located in the floodplain.

Why was the plan created?

Rationale for project/policy: As with all coastal locations, it is projected that Vancouver will be subjected to sea level rise and increased storms over the coming decades and centuries due to climate change. Vancouver was ranked as the 15th most vulnerable to sea level rise in the Coastal Cities at Risk project. This prompted the city to assess its risks to sea-level rise and flooding in order to plan ahead and implement sea-level-rise protection policies.

In 2011, the province of British Columbia issued guidelines on the use of land deemed to be flood hazard areas and recommended assuming there will be 1 metre of local sea-level rise between 2000 and 2100, and an additional 1 metre by 2200.

Who was involved in the creation of the plan?

Stakeholders involved: (internal and external): Consultants and experts from provincial and federal agencies were hired to support the effort. Initial work on recognising the challenges the city faces involved stakeholders comprising city staff and members of invited organisations potentially affected by flood risks and adaptation actions; together these formed an External Stakeholder Advisory Group (ESAG).

Role of political leadership: The mayor and council were supportive and engaged in directing staff throughout the programme.

How was the plan implemented?

Best practice strategies for implementation:

- **'No regret solutions':** The CFRA focused on 'no-regret' solutions that are beneficial to the city no matter the degree of sea-level rise.
- **Incorporating top-down and bottom-up perspectives:** The project combined a top down exploration of hazards with bottom up stakeholder collaborations to identify vulnerabilities.
- **Long-term flood projections:** The risk assessment made projections up to 2100 and 2200, and the 500-year floodplain – to address all eventualities that they can.
- **Varied skillset:** A variety of experts were employed including planning, engineering and GIS specialists.

Challenges/ barriers to be addressed from both a land use and adaptation perspective:

- **Trade-offs:** Phase II of the CFRA involved a 'structured decision making process' where trade-offs were evaluated and options with the best balance across multiple objectives were chosen. This work was done internally with the expectation to conduct extensive public engagement to elicit values and create design principles for future flood management options.
- **Continuity:** Providing ongoing support and ensuring institutional memory of the policy as staff turnover and new development occurred became another challenge.
- **Competing Interests:** it was difficult to balance competing interests and make sure technical solutions also take into account the environment, social wellbeing, and other factors.

[1] City of Vancouver (2014) City of Vancouver Coastal Flood Risk Assessment: Final Report. Available at: http://vancouver.ca/files/cov/CFRA-Phase-1-Final_Report.pdf.

Results of the project:

For Phase I:

- Hazard Analysis/Mapping and high-level vulnerability assessments were used to carry out hydraulic modelling, sea level rise scenarios, and map flood water depths. In 2012, HAZUS, a geographic information system-based natural hazard analysis tool developed by the American Federal Emergency Management Agency was used in Canada for the first time to estimate potential building damage and loss for the various modelled scenarios.

For Phase II:

- Identified risk management options and recommended preferred ones through a structured decision making process that focused on how flood hazard would affect vulnerable populations in additional to buildings and infrastructures.
- Answered questions of cost and risk reduction for each of the different areas.
- Identified preferred flood risk management alternatives and timelines for priority areas.

Lessons learned:

- Hazard, vulnerability and risk assessment programmes take time and should therefore be rolled out in **several phases.**
- It is essential to use many **different skill sets** to accomplish all the objectives. Some aspects were very technical, while others are policy- and planning-intensive.
- **Including an ecological component** to the programme wasn't fully taken into account initially but will now be addressed on a neighborhood by neighborhood basis. This is crucial as there are many trade-offs in a project like this; an infrastructural coastal defense strategy that protects everything may destroy the neighborhood ecosystem it was supposed to be protecting.
- In retrospect, having a **visual component** of the programme to communicate timelines and solutions to staff would be beneficial.

Co-benefits:

Assessing and responding to urban flood risk helps alleviate impacts across several areas.

- **Environmental** – The debris created by a 500-year storm would fill over 4,500 trucks, causing a significant waste concern in the city if no adaptation action was taken.
- **Social** – Under a scenario in which the sea level rises one meter in connection with a 500-year storm, it is estimated that the Climate Change Adaptation Strategy will avoid damage to 800 buildings and the displacement of 14,000 residents.
- **Economic** – Climate-related disaster response costs, including damage to buildings, direct business impacts, city infrastructure costs, and emergency response costs, would be widespread and significant if no adaptation action was taken.

CASE STUDY 3

Cape Town:
Coastal Management Line

While Cape Town's coastline is one of the city's most important socio-economic and environmental assets (contributing approximately 10% to Cape Town's GDP), it may also be a source of climate changed induced coastal risks, such as rising sea levels and frequent storms. Cape Town's Coastal Management Line (CML) ensures that spatial information relating to coastal risks and hazards is used to inform the location of Cape Town's development, thereby promoting risk-averse coastal planning that takes into account climatic changes now and in the future. In addition to building coastal risks into the CML as a spatial planning mechanism to inform development, the CML, through applying a multi-disciplinary approach, also defines nodal growth areas – a means to promote social redress through connecting historically disadvantaged communities to the coast. The inclusion of principles of restorative justice due to south Africa's unequal past – the spatial legacy of which still remains today – has been a key consideration in the establishment of Cape Town's CML.

Project start date:	**2012**
Status of project:	**The Coastal Management Line is in effect over all 240+ km of Cape Town's coastline**
Department in charge:	**Coastal Management Branch of the Spatial Planning and Environment Directorate, City of Cape Town**
Departments consulted/outreach:	**A number of departments within the City of Cape Town, other spheres of government (both provincial and national) as well as various public and community interest groups**
Projects/groups associated:	**The CML is a legal requirement of the Integrated Coastal Management (ICM) Act**

Summary

Goal: Coastal Management Lines were introduced to prohibit or restrict the construction and maintenance of structures seaward of the line. This protects against erosion and future liabilities that may arise as a consequence of inappropriately located structures and ultimately the protection of beaches as public assets Goals of the project included:

- Protecting coastal development against the destructive forces of climate change coastal pressures such as coastal erosion, sea-level rise and storm surges.
- Retaining the socio-economic and environmental asset the coastline provides to the City and its residents.
- Promoting restorative justice through enabling nodal growth opportunities in historically underserved communities Cost: The project was conducted internally as the CML was defined and delineated by City of Cape Town staff.

Hazards addressed: Hydrological and geophysical: The CML prevent the exposure of infrastructure to erosion, storm surges, migrating estuary mouths, and encourages habitat protection through including coastal 'green belts' – which provide a range of ecosystems services and natural buffers – within its spatial area.

Scope: Coastal region of Cape Town.

Why was the plan created?

Rationale for project/policy: The need to promote a risk averse, resilient and equitable coastal city. A Coastal Management Line is a proactive measure used to avoid some of the exposure to climate change induced coastal risks, such as sea-level rise and coastal erosion. They are a critical and proactive socio-institutional intervention to address the escalating pressures associated with climate change and is a relatively cost effective approach as opposed to designing and implementing hard engineering interventions, such as sea walls. The City's CML is a highly variable line, appropriately reflecting the socio-economic and environmental complexities inherent to coastal systems.

Who was involved in the creation of the plan?

Stakeholders involved and how they were engaged: The ICM Act puts a strong emphasis on involving all stakeholders in the coastal management process. The City of Cape Town, in the establishment of its CML, reached out informally with a wide range of Interested and Affected Parties before entering into a formal Public Participation Process. Stakeholders included rate payer associates from around the city, various interest groups, and local ward councilors. Following a widescale public participation process, the CML has been both embedded in the City's Spatial Development Framework and is in the process of being published in the Provincial Gazette in terms of the requirements of the ICM Act.

How was the plan implemented?

Best practice strategies for implementation:

- **A multi-disciplinary approach:** consideration of informants in addition to the empirical analysis of biophysical modelling (such as storm surge, coastal processes, wave run-up etc) where a range of socio-political and environmental factors were considered. The inclusion of such factors are necessary to appropriately reflect the complexity and reality of coastal systems and ultimately the success of implementing a CML as an effective coastal adaptation intervention.
- **Process based:** broad based stakeholder consultation over meaningful periods of time (approx. five years) to build consensus.
- **Knowledge co-production:** consideration of multiple knowledge sets in the establishment of CMLs.
- **Equity focused:** It was recognized that the process was socio-economic as well as physical/environmental, and historical issues of equity and accessibility to the coast were taken into account when designing the line.
- **Flexibility:** The CML recognizes the fact that the coastline is characterized as having emergent risks and there is always some uncertainty in respect of how these systems may change over time, and the degree that such change may take. The socio-institutional approach of the CML is sensitised to this and such an approach retains flexibility, and, as a consequence, promotes option retention into the future.

Challenges/barriers to be addressed from both a land use and adaptation perspective:

Departmental siloing is a challenge that Cape Town may not have entirely resolved.

- This was initially a problem since they were unsure which risk projection to use as well as which other informants should be considered as a baseline for the CML.
- Lack of synchronization of administrative processes linked to the CML – and necessary for its adoption – between different spheres of government.
- Departmental differences within the City as it relates to how CMLs should be established in respect of both type of informants and process .

Outcomes and lessons learned

Co-benefits:

- Environmental: The CML protects more than 240km of coastline, securing biodiversity in the local environment.
- Social: CML helps to address historic injustice of the Apartheid era through promoting restorative justice– it is designed to benefit historically disadvantaged communities while protecting against coastal hazard.
- Economic: Protecting and enhancing the socio-economic value of the coastline by encouraging development that is set back from the immediate coastal environment which will enhance and preserve the benefits provided by the coastline for generations to come.

Lessons learned:

- In the pilot implementation in the Overberg District Municipality there was limited use of local knowledge, stakeholder engagement and transparency, adverse impacts on property rights, and an unrealistic risk projection. These considerations were brought forward for other coastal municipalities to learn from in the establishment of CMLs which is ongoing. Lead agents, based on this experience, have refined the terminology and solicited extensive public input during workshops, instead of going into public discussions with a highly technical and scientific method not understood – and therefore not accepted – by stakeholders and communities impacted by the CML.

CASE STUDY 4

Vancouver: Northeast False Creek Adaptation to Sea Level Rise

Northeast False Creek (NEFC) is the last remaining piece of large undeveloped land in the downtown core along the False Creek Waterfront in Vancouver. The area is vulnerable to flooding due to sea-level rise and storm surge events. Climate change resiliency measures are being planned in order to create a more resilient area, with developments building on the legacy of Southeast False Creek, a neighbourhood previously designed to push the envelope for sustainable development in Vancouver.

Project start date:	**2018**
Status of project:	**in progress**
Department in charge:	**North East False Creek Interdepartmental Project Team**
Departments consulted/outreach:	**Vancouver City Council, Parks Board, Engineering, Planning, Urban Design & Sustainability, Communications**
Projects/groups associated:	**Northeast False Creek Area Plan**

Summary

Goal: Since the construction of southeast False Creek, the City of Vancouver has continued to advance its sustainability goals and targets as outlined in the Greenest City Action Plan. The city has integrated sustainability and adaptation into the plan for the Northeast False Creek (NEFC). Policy highlights include:

- New development must be built at an elevation that is an additional meter over previous construction levels to protect homes and critical infrastructure from future flooding events due to storm surge and rising sea levels.
- A continuous line of flood protection to extend across the site which includes a mix of flood management infrastructure in the format of new seawall typologies, floodwalls and dikes around and set back from the shoreline.
- Exceptional sustainable building design that includes features like green roofs, extensive green infrastructure and connections to neighbourhood renewable energy systems.

Cost: Funding to support planning services for this project came from the Sustainability Group budget at the City of Vancouver, amounting to one full-time employee for 8–12 months.

Hazards addressed: Hydrological – to manage the vulnerability to flooding from sea-level rise and storm surge and extreme rain. Seismic hazards are also considered in the planning and design of NEFC given the region's seismic event probability.

Scope: One neighbourhood located in downtown Vancouver.

Why was the plan created?

Rationale for project/policy: Northeast False Creek is the last remaining piece of large undeveloped land in downtown Vancouver and the site had already been remediated through capping contaminated soils on site. The waterfront is also vulnerable to flooding due to sea level rise and storm surge. This project provides an opportunity to embrace the area's culture and history and protect its assets with respect to the impacts of sea level rise and storm surge while creating a new community in the urban core.

Who was involved in the creation of the plan?

Stakeholders involved: In 2015, the Vancouver City Council decided on a plan to replace the viaducts in the False Creek area with a more resilient and connected street network. To accomplish this, the Northeast False Creek area first needed a new area plan. Since the community is in a region vulnerable to flooding, it made sense to enlist the help of the Sustainability Group and bring on a full-time employee to complete this work as part of the development of the (NEFC) Plan (2016-2018). From 2017-2018, the Sustainability Group embedded the staff member into the Northeast False Creek project team which also includes staff from the Parks Board, Engineering, Planning and Communications teams.

Role of political leadership: On 25 July 2012, City Council approved the Climate Change Adaptation Strategy recommending that staff undertake a suite of priority actions. This included examining the potential impacts of sea level rise on the city along the coast line. Additionally, in 2012, the city initiated the Coastal Flood Risk Assessment (CFRA) program to study what these changes might be, how the city might be affected by them, and what options exist to minimize harmful impacts.

How was the plan implemented?

Best practice strategies for implementation:

Proactive planning: The False Creek area is not in immediate danger from flooding, so this is a proactive measure that is well integrated with the planned development timeline. The city of Vancouver is planning for 2050 and 2100 and so aims to invest in planning principles and designs that will make the area resilient to the impacts of flooding.

Challenges/barriers to be addressed from both a land use and adaptation perspective:

Physical site considerations: The NEFC site has already been remediated through capping contaminated soils on site, but managing the contaminated sites will still be an issue as the new construction will dig into some parts of the contaminated area, thereby triggering further remediation.

Outcomes and lessons learned

Results of the project:

The project is still underway so results are pending and the risks it is planning for are also difficult to measure. However the protection and social benefits are expected to pay off many times over. The NEFC area is a large part of downtown Vancouver and transforming it into a vibrant and sustainable mixed-use area is a huge step forward.

Lessons learned:

Expertise on sustainability: Initially the NEFC did not have a full-time advisor, just someone from the Sustainability Group providing advice in addition to their other responsibilities. The full-time sustainability planner was brought on at that point on a temporary basis, but in retrospect should have been part of the team from the beginning.

[1] City of Vancouver (n.d.) Sustainability and Resiliency in the Northeast False Creek Plan. Available at: http://vancouver.ca/home-property-development/northeast-false-creek-sustainability-and-resiliency.aspx.

CASE STUDY 5

Washington, DC: Green Area Ratio

The Green Area Ratio (GAR) is a zoning regulation that integrates sustainable landscape elements into site designs to address higher ambient temperatures and manage stormwater in Washington, DC. The GAR's flexible green site requirements set out minimum coverage standards for landscape and site design features to incorporate green spaces to promote greater livability, ecological function, and climate adaptation in the urban environment. For each site that triggers the GAR requirements, the applicant must hire a certified landscape expert to ensure that landscape requirements are met.[1]

Project start date:	**Effective since October 2013, revised in September 2016**
Status of project:	**In progress: in July 2020, 238 projects had completed final inspection approval**
Department in charge:	**DC Office of Planning in collaboration with the Department of Energy and Environment**
Departments consulted/outreach:	**DC Office of Zoning, Centre for Watershed Protection, Department of Consumer and Regulatory Affairs, the DC Zoning Commission.**

Summary

Goal: Increase green spaces in DC by setting out flexible building guidelines that can be achieved in a variety of ways. The key reasons for this were to increase liveability, create ecosystem services, and help DC adapt to climate change. By increasing green cover, DC hoped to achieve the following:

- reduce stormwater runoff,
- improve air quality, and
- reduce the urban heat island effect.

Cost: The costs of implementing the GAR regulations are dependent on the project. Applicants must pay initial, final, and supplementary review fees when applying for their building permit. These fees fund the programme itself.

Hazards addressed: Climatological – Extreme heat is an issue in DC, with the city suffering from one of the most intense urban heat island effects within the US. Also, expanding green space addresses hazards associated with heavy rain events including flooding and deterioration of water quality.

Scope: The GAR applies citywide and varies by zone.

Why was the plan created?

Rationale for project/policy: The main challenges to be addressed are the urban heat island effect and the need to manage stormwater runoff (which is made difficult by the lack of public green space in the city). Increasing green spaces and roofs would lead to reducing storm water runoff, improving air quality and decreasing the temperature of the city. The revisions to the GAR were also inspired by similar programmes in Berlin, Seattle, and Malmö.

Who was involved in the creation of the plan?

Stakeholders involved:

The project was led by the Office of Planning following an update to the District's zoning code, which hadn't been updated since 1958. The plan also involved several city departments: The Department of Consumer and Regulatory Affairs, Department of Energy and the Environment, and the DC Office of Zoning.

Role of political leadership:

DC is a progressive city with broad political support for environmental policies. The first green building requirements were implemented over a decade ago and are now accepted as part of the development process by the real estate development community.

How was the plan implemented?

Best practice strategies for implementation:

- **Achievable GAR targets:** The city provided many ways for buildings to meet the GAR targets including permeable pavements, green roofs, rain gardens, natural ground cover, and more.
- **Clarifying regulations and responsibilities:** The 2016 update clarified some of the language of the regulation and ensured the GAR was coordinated with other requirements. This included the Department of Energy and Environment (DOEE's) stormwater management and sediment erosion control regulation. The Zoning Commission set the minimum score that buildings subject to the GAR have to meet according to the zone they are located in, while DOEE provides technical expertise on environmental factors.
- **Public and accessible training:** There are regular training sessions four to five times a year on how to comply with the requirements. These sessions are free and open to the public and clarify the difference between the GAR and the stormwater management guidelines.
- **Financial incentives:** Builders and developers have access to a wide variety of financial incentives to help meet the GAR requirements, primarily through the District's Stormwater Retention Credit Trading System, (many of the requirements between the stormwater regulations and GAR overlap).

Challenges/ barriers to be addressed from both a land use and adaptation perspective:

- **Cross-coordination:** Since the project involves so many departments, each with its own regulations and standards of measurement (stormwater management, sediment control, solar permits, and standard building and construction requirements), it is difficult to track requirements. Effective coordination is necessary to avoid redundancy, and ensure reviews are consistent and streamlined.
- Other challenges include the **maintenance and design aesthetics** of the green infrastructure, and questions of **equity and access**, as projects subject to the GAR are often not implemented in areas where the urban heat island effect impacts the most vulnerable.

Results and outcomes

Results of the project:

238 projects, as of July 2020, had completed the final review process, spanning a range of zones and uses.

Lessons learned

- **A 'one-size fits all' citywide approach to GAR requirements may not necessarily be ideal**; i.e., it may be more effective to require higher GAR scores in some areas of the city to mitigate particular environmental issues. For example, the city could consider requiring a higher number of heat mitigating landscape elements where the urban heat is particularly problematic.
- **Integrating different regulations with one another:** DC has a history of implementing green building regulation and the GAR is just one tool to increase sustainability, as part of a holistic effort pursued by different departments. By fulfilling the requirements of the GAR, developers can therefore be compliant with other regulations already in place (for instance the pervious surface zoning requirement, stormwater requirements, the green building code, renewable energy requirements and so on). The set of GAR requirements is only one of several pieces of environmental regulation that have been gradually integrated into the city's building process.
- **Flexibility** is key to success: GAR implementation was successful because of the number of paths to compliance offered to developers.

Co-benefits

The District is currently evaluating the effects and co-benefits of the GAR, particularly in terms of equity and health-related health impacts. In particular, the District is studying how the GAR can be better used to mitigate the urban heat island effect, since urban heat has a negative impact on sensitive populations.

[1] See more details at: Department of Energy and Environment (2019) Green Area Ratio Handbook. Available at: https://doee.dc.gov/sites/default/files/dc/sites/ddoe/service_content/attachments/GARGuidebook_FINAL_November2017_0.pdf.

CASE STUDY 6

London:
Greening the BIDs

The Greater London Authority (GLA) and Cross River Partnership are working together on a public–private partnership to identify how Business Improvement Districts (BIDs) can deliver opportunities for increasing green cover in their areas. BIDs are a mechanism for property and business owners to make a collective contribution to the maintenance, development, and promotion of their commercial district, through a self-imposed levy.[1]

Project start date:	**Launched in 2010**
Status of project:	**Complete: 19 green infrastructure audits, 117 projects completed; most BIDs now delivering their own greening programmes**
Department in charge:	**Greater London Authority**
Departments consulted/outreach:	**Transport for London, London Boroughs**
Projects/groups associated:	**The Cross River Partnership, a public–private partnership originally formed to facilitate cross-river projects in London such as the Millennium Bridge**

Summary

Goal: Increase the amount of green cover in BIDs to improve the public realm by lessening the urban heat island effect, reducing surface water flood risk and enhancing biodiversity. This supports previous Mayor of London goals of increasing central London's green cover by 5 per cent by 2030 and 10 per cent by 2050, and current plans to ensure at least half of London is green by 2050.[2]

Cost: The cost of identifying and implementing green cover varies depending on the project. So far, around £2.5 million (USD 3.24 million) has been invested.

Hazards addressed: Meteorological: the urban heat island effect creates higher temperatures in cities, sometimes to a dangerous degree. Urban greenery reduces this effect, while also reducing surface water flooding from extreme rainstorms.

Scope: Any BID, employer partnership, or manager of a public/private estate in London could participate.

Why was the plan created?

Rationale for project/policy: To meet the mayoral targets for green cover in central London, the GLA turned to the BIDs as a solution because they represent owners of properties who could be encouraged to install green roofs, green walls and rain gardens on privately owned land and buildings, which would provide public benefits. One of the main motivations behind this project is central London's vulnerability to extreme heat and surface flooding, and the economic impact this could have; central London generates almost 10% of the UK's economic output and one third of jobs in London are located here.

Challenges/barriers to be addressed from both a land use and adaptation perspective:

- Lack of public space: One of the key challenges for implementing climate change adaptation initiatives in central London is the lack of public space. Despite having expansive green spaces such as St James's Park and Green Park, much of central London is densely developed; consequently, it is necessary to encourage greening of the existing built environment to meet adaptation and green infrastructure objectives. For regeneration and new development, this is done through urban planning policies in the London Plan, including the new Urban Greening Factor, encouraging the installation of features such as green roofs and green walls.[3] But a significant increase in green cover relies on the retrofit of existing buildings by property owners and managers.
- Lack of financial incentives: There are no significant financial incentives for private-sector property managers to retrofit their buildings with green infrastructure. Therefore the project focused on the fulfilment of corporate social responsibilities through greening, and the co-benefits of improving the public realm and workplace environments.

Who was involved in the creation of the plan?

Stakeholders involved:

A "Greening the BIDS" steering group was created, with representatives from the BIDs, the Greater London Authority, and the Cross River Partnership to share ideas, solutions, and best practices.

Role of political leadership:

The original impetus for the project came from the Mayor's commitment to increase green cover in central London. However, the initiative gave local businesses autonomy in determining the projects that fit best with their commercial and corporate social responsibility objectives.

How was the plan implemented?

Best practice strategies for implementation:

- **Green Infrastructure Audits:** Conducting detailed audits was crucial to identify opportunities for increasing green cover in a BID area, as well as potential benefits of the project.
- **Incentivising businesses:** The GLA provided initial grant funding and financial support to BIDs as an incentive to conduct green infrastructure audits.
- **Incorporating existing buildings:** The scheme also includes retrofitting older buildings to maximise the potential for increasing green cover.
- **Stakeholder enthusiasm:** The Victoria BID was the first to complete a Green Infrastructure Audit, and published a best practice guide to assist other districts.[4]

Outcomes

Results of the project:

The GLA has supported 19 green infrastructure audits in 19 different BIDs in central London, covering over 500 hectares of land. The audits identified the potential for the development of 300 rain gardens, 200 green walls, and more than 100 hectares of green roofs, in addition to more traditional interventions such as planting of street trees. The GLA has provided 25 per cent of the funding in 16 green retrofit projects. In addition, a similar initiative, Wild West End, has since been initiated by the central London estate companies.

Co-benefits:

- **Economic:**
  - Green infrastructure can increase commercial trading by up to 40 per cent.[5]
  - Energy consumption reduction.
- **Environmental:**
  - Improvement of air quality.
  - Potential to reduce damages from floods.
  - Improvement of urban wildlife habitats.
  - Reduction of the urban heat island effect.
- **Health/Social**
  - Reduction of the severity of heat waves.
  - Better quality public realm and more space for walking and cycling.

Lessons learned

- **Interacting with the private sector:** The key lesson learned is that the private sector can be an active and willing participant in urban greening initiatives when the public sector provides it with support to identify where private assets and influence can be used to best effect. Prior to the development of the Greening the BIDs initiative, many of the BIDs were supporting more traditional public realm improvements, such as funding the installation of hanging baskets and floral displays. However, once they were alerted to the opportunity of strategic greening initiatives, they were prepared to invest resources into projects with more lasting environmental outcomes.
- **The value of in-between organisations:** Another key lesson is that organisations that can broker partnerships between the public and private sector play a crucial role. Greening the BIDs was administered by the Cross River Partnership, which interprets public sector policy objectives and translates them into a narrative that is compelling to private- sector partners. By co-ordinating and championing this new area or policy through the Greening the Bids initiative Cross River Partnership provided the necessary support and momentum to encourage individual BIDs to develop and support their own greening programmes.
- **The importance of addressing new and emerging challenges:** although climate resilience remains a key driver for many of the greening projects, the ompotance of urban greening for health has become an equally important objective, particularly as creating healthy working environments can help attract and retain staff and provide a wider public benefit.[6] This has been brought into even sharper focus as a result of of the Covid pandemic which points to the need to transform more central London streets into greener, civic space for walking and cycling. This has resulted in Cross River Partnership establishing a Healthy Streets Everyday initiative.

[1] For more information about BIDs, see: Mayor of London (n.d.) 'About Business Improvement Districts'. Available at: www.london.gov.uk/what-we-do/business-and-economy/supporting-business/about-business-improvement-districts

[2] For more information, see Mayor of London (2011) 'Managing Risks and Increasing Resilience'. Available at: www.london.gov.uk/sites/default/files/gla_migrate_files_destination/Adaptation-oct11.pdf

[3] For more information about the Urban Greening Factor, see TCPA (2017) 'Planning for Green Infrastructure'. Available at: www.interregeurope.eu/fileadmin/user_upload/tx_tevprojects/library/file_1551105810.pdf

[4] Victoria Business Improvement District (2013) Green Infrastructure Audit: Best Practice Guide. Available at: www.victoriabid.co.uk/wp-content/uploads/2014/10/BestPracticeGuide_A4-10.pdf

[5] City of London (2016) Green Capital: Green Infrastructure for a Future City. Available at: www.london.gov.uk/sites/default/files/green_capital.pdf

[6] Cross River Partnership (2018) 'Healthy Greening in Central London' https://crossriverpartnership.org/wp-content/uploads/2019/04/Healthy-Greening.pdf

CASE STUDY 7

New York: Climate Resiliency Design Guidelines

The City of New York is currently piloting guidelines on how to integrate climate resiliency into building and infrastructure. The rollout and pilot testing will help determine how the guidelines are improved, applied, and ultimately enforced throughout the city capital programme.[1]

Project start date:	**Preliminary guidelines were released in April 2017**
Department in charge:	**The Mayor's Office of Recovery and Resiliency (ORR)**
Departments consulted/outreach:	**The New York City Panel on Climate Change provided the science behind the guidelines and a working group of 15 city agencies co-developed and piloted the guidelines.**
Projects/groups associated:	**The Climate Resiliency Design Guidelines are part of the OneNYC Initiative, the city's plan for a just, strong, sustainable, and resilient city, as well as are part of the city's $20 billion multi-layered resiliency programme**

Summary

Goal: The goal is to incorporate projected climate data into the design of all of New York City's capital projects, and provide a consistent methodology to do so. This will:

- Increase the climate resilience of the city in the face of frequent floods due to sea level rise; and
- address the hazards of extreme heat and precipitation within the city.

Cost: The guidelines were written in-house using city expertise, therefore incurring no extra costs. This took approximately six months. However, an outside engineering design firm was brought on after the preliminary guidelines were first released, to conduct the pilots and help update the guidelines.

Hazards addressed: Hydrological and meteorological – addresses future risks from floods, sea level rise, heat, and precipitation.

Scope: Currently the guidelines only apply to municipal building and infrastructure projects, although private companies are encouraged to use the guidelines as well.

Why was the plan created?

Rationale for project/policy: Hurricane Sandy revealed vulnerabilities in New York's infrastructure and buildings. This was a strong motivating factor to increase the city's resilience to hurricanes and resulting floods, since these events will increase in the future.

Challenges/barriers to be addressed from both a land use and adaptation perspective:

The guidelines are being iteratively improved as they are piloted and implemented by city agencies. Some of the challenges being addressed include:

- Demonstrating the value of climate resilience: NYC has used a pilot period to test and demonstrate the value of climate resilient design. This is important to identify where higher upfront costs may be incurred, and to justify these costs in order to avoid future damages and higher operational costs.
- Consistency but flexibility across guidelines: Guidelines must be consistent and easy to use across a wide range of city agencies. This goal was met by using input from all the agencies in developing the guidelines and ensuring that the resilient design recommendations were flexible.
- Using targeted data: The data from the New York City Panel on Climate Change was essential to developing the guidelines, but it was also academic, meaning it gave a wide range of possible risk scenarios when what engineers and architects need are specific numbers to base their designs on. The guidelines are set in the middle range for flood design, but with flexible adaptation pathways that can be increased as needed. When planning for heat and precipitation, the standards were set at the higher end of the projections because it's much more difficult to adapt those systems later on.

Who was involved in the creation of the plan?

Stakeholders involved:

Representatives from a number of city departments and agencies contributed to the guidelines, including: Environmental Protection, Transportation, City Planning, Buildings, Design and Construction, Parks and Recreation, Emergency Management, School Construction Authority, City Administrative Services, Health and Hospitals, Information Technology and Telecommunications, Economic Development Corporation, Housing Authority, Public Design Commission, Mayor's Office of Sustainability, Housing Preservation and Development, Office of Management and Budget, Sanitation and Law.

Role of political leadership:

The project has received support from city leaders and demonstrates how strong leadership and sustained cooperation among agencies can result in a highly effective and actionable product.

How was the plan implemented?

Best practice strategies for implementation:

- **Worldwide consultation and best-practice:** The Office of Recovery and Resiliency (ORR) consulted with cities and entities around the world who had planned and completed similar projects. For example, the importance of including all design-related agencies in drafting the guidelines was emphasized in discussions with San Francisco.
- **Evidence-based guidelines:** Consultants had access to extensive local climate data gathered and analyzed over the past 10 years by the New York City Panel on Climate Change, and the collective knowledge and input of 15 different city departments and agencies. Having such a strong scientific basis for the guidelines was essential to using them as a foundation for city policy and recommending changes to design that go beyond building code and engineering standards.
- **Engaging city-officials:** High-ranking city officials across many different agencies have confirmed their support in press releases and public appearances.
- **Substantial timescale for piloting:** The city took two years to test pilot the guidelines and determine improvements that could be made. These improvements were incorporated into the third version of the guidelines, released in March 2019. Work continues to refine the guidelines and prepare them for broader and potentially mandatory application.

Outcomes

Lessons learned:

- **Consultation with other cities** and **robust stakeholder engagement** involving as many agencies/ departments as possible were essential in developing guidelines that are effective and efficient.
- This is not an entry-level adaptation project because **detailed localized climate data** and strong leadership and **interdepartmental coordination** are essential prerequisites for success.
- The project is a **long-term process**. Even though the guidelines themselves were completed fairly quickly with minimal extra costs, New York City is trying to create a deep-seated change in the way people think about design and maintenance of the built environment. The guidelines have also been tested and updated iteratively for four years to reflect lessons learned and refine the process.

Results of the project:

The guidelines provide a framework for people involved in building/design to make buildings and infrastructure resilient to future climate change threats. The ORR is now working on ways to demonstrate tangible results and savings. For now, the guidelines aren't mandatory and don't apply to everyone, only city capital projects shown to be at risk from climate impacts. In late 2019, NYC's City Council indicated that they are planning to make the guidelines mandatory for all public capital projects.

Co-benefits

The guidelines are expected to reduce damage from flooding, extreme precipitation, and extreme heat at public facilities, as well as support communities with high vulnerability to the urban heat island effect.

[1] See more details at: NYC Mayor's Office of Recovery and Resiliency (2019) Climate Resiliency Design Guidelines, v. 3. Available at: www1.nyc.gov/assets/orr/pdf/NYC_Climate_Resiliency_Design_Guidelines_v3-0.pdf.

CASE STUDY 8

Rotterdam:
Water Square Benthemplein

Rotterdam's water square retains water during rainfall, easing the stress on sewage systems and preventing floods in highly urbanized areas. The square is designed around a community area, which during dry times is used as a sports pitch and recreational space for the community to enjoy and use.[1]

Project start date:	**June 2009**
Status of project:	**Officially opened in December 2013**
Department in charge:	**City of Rotterdam and De Urbanisten (architectural firm)**
Departments consulted/outreach:	**Schieland and Krimpenerwaard Water Board**
Projects/groups associated:	**Waterplan II & Rotterdam Adaptation Strategy**

Summary

Goal: The water square was designed to store and manage water during heavy rainfall periods lasting longer than 45 minutes, to ease pressure on Rotterdam's sewage system, and prevent flooding. The main goals are to:

- capture and contain stormwater, and
- serve as a community space during drier periods, to be used by students from the nearby school as well as by the wider community for recreational activities.

Cost: Approx. €4.2 million; €1 million from Schieland and Krimpenerwaard Water Board, €1 million from the city of Rotterdam, remainder from the EU and the Dutch government, including the Ministry for the Infrastructure and Environment and Mooi Netherland (subsidy scheme for Beautiful Netherlands project).

Hazards addressed: Hydrological – the city suffers from surface flooding caused by extreme rainstorms which overload the sewage system.

Scope: One water square in the Benthemplein neighbourhood (the model is being expanded to more squares in Rotterdam).

Why was the plan created?

Rationale for project/policy: Rotterdam does not have a lot of green areas, and most of the canals and water storage areas are outside the city, requiring the bulk of water storage to happen in the densely populated centre. Much of the city is also below sea level, so excessive rainfall amounts have to be pumped out or stored. Therefore, green roofs are not sufficient to store millions of litres of rainwater. Underground catchment tanks are an expensive solution due to the high groundwater levels in the Netherlands. Furthermore, these are not visible to taxpayers, and are more difficult to get political support for.

The Benthemplein area was a particularly high-risk flood zone, and an area where the local community requested improvements to the square.

Challenges/barriers to be addressed from both a land use and adaptation perspective:

- The first water square that Rotterdam tried to implement as a pilot project, Bloemhof Square, failed due to a lack of stakeholder engagement. Parents in the neighbourhood were concerned about large amounts of standing water presenting a drowning hazard for small children. Additionally, because previous improvements had been made on the square three years prior, the community did not feel the need for the extensive remodelling that a water square would require. To plan for the Benthemplein Water Square, the stakeholder engagement process was much more intensive.
- The departments of city planning and city maintenance were able to develop effective ways of working together, overcoming the challenges of having multiple project partners and stakeholders.

Who was involved in the creation of the water square?

Initiation of the project: The general concept of a water square was suggested in 2008 through the Waterplan II, part of Rotterdam's Climate Proof initiative. Plans for the Benthemplein square were initiated when students from the nearby high school requested that their local square be remodelled.

Stakeholders involved:

- City of Rotterdam departments such as: city planning, city maintenance, engineering bureau, and health. The health department mandated that water could only be stored in the square for 24 hours before being pumped away.
- Private firms including De Urbanisten (an architectural firm) and businesses surrounding the square such as a sports and health club.
- Public stakeholders: residents, parishioners of a local church, and community liaisons.

Role of political leadership:

Political leaders were mostly supportive: water squares are an appealing and exciting public project. The idea for a water square had originated from the city government and Benthemplein was an opportunity to implement it.

How was the plan implemented?

Best practice strategies for implementation:

- **Community engagement:** Extensive input from surrounding communities ensured that the square served local needs and was valued in the area.
- **Participatory meetings:** At the first community planning meeting, designers organized a wish-based game to determine what residents wanted from the water square. At the next meeting, designers presented three different designs to the community and asked participants specific questions on what they liked about them, focusing mainly on the positives.

Lessons learned

- **Community engagement:** Engaging with the community and taking residents' suggestions as to the water square's location and features helped to make the project successful.
- **Simplicity is key:** The more aesthetically and technically advanced an infrastructure project is, the more expensive it will be to build and maintain. Rotterdam's recommendation for water squares is to have as few technical features as possible: for instance, water flowing freely into drains, as opposed to water that must be pumped. Further water square plans incorporated lessons from the Benthemplein square. For example, more recent water squares are accessible to cars for cleaning purposes and fitted with a slope to prevent water from remaining stagnant in the square playing field.
- **Maintenance costs:** The cost of maintenance has proven to be quite high: the water square requires daily cleaning and a deep clean four times a year, at a total annual cost of €75,000. This is partly due to design limitations and partly due to its use: community users of the water square do not keep it clean, and aren't encouraged to do so, as it gets cleaned every day. There has not been an extensive cost-benefit analysis on the water square model.
- **Additional designs:** Some improvements had to be made after the square's completion to provide drinking water, the lessons of which have been incorporated into the designs of future water squares.

Co-benefits:

- **Social:** The nearby high school uses the square as an outdoor recreation space to play sports, and the whole community benefits from a pleasant open space.
- **Health:** The square reduces the risk of sewage floods, therefore reducing the risk of waterborne diseases.
- **Economic:** By reducing sewage flood risk, the water square alleviates costs related to flood damage and sewer repair. Instead of enlarging sewer pipes, which are not visible to the public, public funds are spent on upgrading the public space.

Results of the project:

During rainfall, water is collected in the three basins of the square. It will then drain into the soil or will be funnelled to canals elsewhere in the city. According to city officials, the three basins that make up the water square hold up to 1.7 million litres of water (1,700 m3).

[1] See more details at Urbanisten (n.d.) 'Water Square Benthemplein'. Available at: www.urbanisten.nl/wp/?portfolio=waterplein-benthemplein

CASE STUDY 6

Singapore: Bishan-Ang Mo Kio Park

The Kallang River in Singapore runs through Bishan-Ang Mo Kio Park. Previously a concrete canal, it was transformed into a naturalized river with bioengineered edges that meanders through the park. Singapore's National Water Agency (PUB) and National Parks Board (NParks) worked together with consultants Ramboll Studio Dreiseitl and CH2M Hill Singapore on an innovative drainage improvement project to increase the capacity of the waterway while providing a green space for the public to enjoy.[1]

Project start date:	**The design consultancy ran between 2007 and 2010, and construction took place from 2009 to 2012**
Status of project:	**Complete**
Department in charge:	**Joint collaboration between PUB and NParks**
Departments consulted:	**Urban Redevelopment Authority, Ramboll Studio Dreiseitl**
Projects/groups associated:	**The redevelopment of the park was carried out under the Active, Beautiful, Clean Waters (ABC Waters) Programme, a long-term strategic initiative to enhance Singapore's waterbodies and help residents appreciate them**

Summary

Goal: The overarching goal of the application of the ABC Waters Programme on the stretch of the Kallang River at Bishan-Ang Mo Kio Park was to enhance drainage infrastructure and to give residents access to the water. The project's main focuses were to:

- increase capacity of the concrete river channel through bio-engineering to prevent the nearby roads from flooding during heavy rainstorms, and
- provide a more natural and beautiful area for wildlife and city residents.

Cost: SGD 76.7 million (USD 56.3 million).

Hazards addressed: Hydrological – reducing the risk of flooding due to river overflow in heavy rains.

Scope: The scope of this project was limited to Bishan-Ang Mo Kio Park, but the ABC Waters Programme applies citywide.

Why was the plan created?

Rationale for project/policy: In Singapore, rainfall statistics since 1980 have shown an increasing trend in the frequency of heavy rainfall events. When designing the expansion of the Kallang River to cater for higher-intensity storms, PUB did not adopt the conventional approach of creating a bigger concrete drain. Instead, it worked with NParks to explore how the river could be integrated into the picturesque Bishan-Ang Mo Kio Park. This would allow the river to carry a higher flow of stormwater while increasing the pleasantness of the park for residents.

Who was involved in the creation of the water square?

Stakeholders involved:

PUB launched the ABC Waters Programme in 2006. By integrating the drains, canals, and reservoirs with the surrounding environment in a holistic way, the ABC Waters Programme aims to create beautiful and clean streams, rivers, and lakes with enhanced public spaces for the community to enjoy. PUB worked closely with government agencies and consultants to develop watershed masterplans. Subsequently, PUB solicited public feedback in workshops and outreach campaigns, and held an exhibition in 2007 to invite the community to learn more about their projects.

Bishan-Ang Mo Kio Park, under the purview of NParks, is one of the biggest and most popular parks in Singapore and had not had a major upgrading since it was built in 1988. At the same time, PUB also had plans to upgrade the Kallang River. Given this, NParks and PUB reviewed their individual development plans and the project became a joint collaboration between both agencies.

Role of political leadership:

Political leaders were onboard with the ABC Waters Programme from the beginning. One such advocate was Dr Yaacob Ibrahim, then Minister of the Environment and Water Resources. The first ABC Waters demonstration project was rolled out in his ward, showcasing to residents what waterfront living could be. The programme also received support from the late Mr Lee Kuan Yew, the first prime minister of Singapore, who publicly praised it and commended Singaporeans for keeping the city's waters clean.

How was the plan implemented?

Best practice strategies for implementation:

- **Extensive research and new technologies:** An essential component of the project was soil bioengineering, which needed to be tested in order to be successful. Over an 11-month period, 10 strategies were tested, to ensure that the park could function as a floodplain. As a result of the tests, a variety of plants and bedding materials were used to stabilize the riverbanks, and different wetland plants were introduced for natural cleaning. The park also includes green roofs and bioswales, which slow down water and help remove coarse pollutants.
- **Public engagement and education:** Because one of goals of the project was for residents to enjoy the renovated park and riverbanks (and understand the need for climate adaptation measures), public engagement was essential. During the design phase of the project, PUB engaged extensively with the residents in the park area. PUB also encouraged schools to take their students into nature and help them understand the importance of the water in the park. This project had a more intensive level of public engagement than PUB had ever attempted before.

Challenges/ barriers to be addressed from both a land use and adaptation perspective:

- **Working across public agencies:** PUB and NParks, the two main agencies in charge of the project, had to adjust their goals: PUB, as the water agency, was concerned with creating an efficient stormwater conveyance channel, while NParks was focused on creating a quality living environment. Prior to the renovation of the park, the areas that each agency was responsible for were clearly demarcated. To integrate the waterway into the park, the agencies held many discussions to understand each other's roles and responsibilities and to establish common ground and shared goals. The end result meets both agencies' goals, with a park that's appreciated by residents for its extensive greenery and natural space, and a new waterway that can retain even more stormwater than before.
- **Concerns over flooding:** Some residents were concerned with the flooding of the park after heavy rains, as they were unaware that the banks of the river were designed as part of the stormwater conveyance channel. The agencies in charge and some media outlets corrected this misconception by reiterating the park's mission.
- **Sustainable construction methodology:** Efforts were made to reduce tree cutting to a minimum, and trees assessed to be in poor form were recycled as construction materials for the river embankment or as park furnishings. Concrete from the old canal was reused.

Outcomes and lessons learned

Results of the project:

- The 2.7 km long drainage channel is now a **3 km river.** According to city stakeholders, the land of the park is now being used in a much more effective way.
- The park now includes vegetated habitats **that cleanse the rainwater** runoff before it goes into the waterway. The transformed Kallang River at Bishan Ang Mo Kio Park is connected via the drainage network to the city's Marina Reservoir, allowing the water to drain away once the rain stops.

Lessons learned:

- Singapore thoroughly tested and then selected innovative bioengineering techniques to naturalize the park.
- The project achieved more than just preventing urban floods; it also increased enjoyment of the natural environment and educated the general public about water in natural spaces.

Co-benefits:

- **Social:** The park is more enjoyable for residents and visitors with a naturalized river than with the previously existing concrete canal.
- **Health:** As the park is more desirable, it is more likely to be used for recreational activities with health benefits, such as sports and exercise.
- **Economic:** The renovated park increased property values and contributed to making the area more appealing for businesses.
- **Environmental:** Biodiversity has increased in the park, with regular sightings of otters, egrets, and more.

Awards and accolades

The ABC Waters project at Kallang River at Bishan-Ang Mo Kio Park has won many local and international awards. Some of these accolades include the 'Landscape of the Year' Award at the World Architecture Festival 2012, the 2012 Waterfront Center Awards' Environmental Award and, more recently, the Honour Award at the 2016 American Society of Landscape Architects Professional Awards.

[1] See more details at: Atelier Dreiseitl (n.d.) 'Bishan – Ang Mo Kip Park and Kallang River'. Available at: http://blogs.gsd.harvard.edu/loeb-fellows/files/2012/11/AD-Ref_Singapore_Bishan-Park.pdf

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