GOOD PRACTICE GUIDE

Climate Change Adaptation in Delta Cities

C40 CITIES
CLIMATE LEADERSHIP GROUP

C40 Cities Climate Leadership Group

The C40 Cities Climate Leadership Group, now in its 10th year, connects more than 80 of the world's greatest cities, representing 600+ million people and one quarter of the global economy. Created and led by cities, C40 is focused on tackling climate change and driving urban action that reduces greenhouse gas emissions and climate risks, while increasing the health, well-being and economic opportunities of urban citizens. www.c40.org

The C40 Cities Climate Leadership Group has developed a series of Good Practice Guides in areas critical for reducing greenhouse gas emissions and climate risk. The Guides provide an overview of the key benefits of a particular climate action and outline successful approaches and strategies cities can employ to implement or effectively scale up these actions. These Guides are based on the experience and lessons learned from C40 cities and on the findings and recommendations of leading organisations and research institutions engaged in these areas. The good practice approaches are relevant for cities engaged in C40 Networks as well as for other cities around the world.

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More than two-thirds of the world's largest cities are coastal delta cities. These cities are vulnerable to rising sea levels as a result of climate change, while millions of people are already being exposed to the risk of extreme storms and flooding events. By the middle of this century, the majority of the world's population will live in cities in or near deltas, estuaries or coastal zones, increasing the number of people facing these impacts globally. Such socio-economic trends further amplify the possible consequences of extreme climate change related events and the vulnerability of delta cities is expected to increase in the decades to come.

Any strategy for the sustainable development and growth of delta cities must integrate adaptation planning in order to reduce vulnerabilities to climate change risks and impacts. This Good Practice Guide identifies a number of Good Practice Approaches for climate change planning and implementation in delta cities:

- **Take an integrated land use and water systems approach**
- **Engage community and other stakeholders in coastal and riverside land use planning**
- **Manage rainwater**
- **Manage groundwater table and land subsidence in relation to sea-level rise**
- **Consider the water balance: freshwater supply and source protection of rivers**
- **Adopt a multi-risk approach**
- **Utilise priority budgeting and creative financing for long-term security**

The C40 Connecting Delta Cities (CDC) Network was established to support delta cities in C40 to mainstream adaptation policies and approaches to deliver concrete climate change adaptation action by facilitating the sharing of good practice and technical expertise. The purpose of this Good Practice Guide is to summarise the key elements of CDC good practice for global dissemination, highlighting the success of C40 cities in planning and delivering climate change adaptation measures.

1 BACKGROUND

1.1 Purpose

C40 Cities Climate Leadership Group is developing a series of Good Practice Guides in areas critical for reducing GHG emissions and managing climate risks. The C40 Good Practice Guides provide an overview of the key benefits of a particular climate solution and outline good practice principles based on activities and strategies successfully employed by C40 cities. These Guides are based on the experience and lessons learned of C40 cities working together in specific C40 networks and also draw on findings and recommendations of leading organizations and research institutions engaged in these areas.

The following Good Practice Guide focuses on the key elements required to successfully deliver climate change adaptation in delta cities, with a survey of good practice principles leading to better economic, social, and environmental outcomes for cities. These approaches are drawn from the experiences of cities engaged in C40's Connecting Delta Cities Network and are relevant for coastal river delta cities around the world.

1.2 Introduction – Why Delta Cities?

More than two-thirds of the world's largest cities are coastal delta cities. These cities are vulnerable to rising sea levels and frequent floods as a result of climate change, where millions of people are already being exposed to the risk of extreme storms and flooding events. By the middle of this century, the majority of the world's population will live in cities in or near deltas, estuaries or coastal zones, increasing the number of people facing these impacts globally. Such socio-economic trends further amplify the possible consequences of extreme climate change related events and the vulnerability of delta cities is expected to increase in the decades to come.

Any strategy for the sustainable development and growth of delta cities must integrate adaptation planning and implementation in order to reduce vulnerabilities to climate change related stresses and disasters, incurred losses, and costs for cities.

2 CLIMATE CHANGE ADAPTATION IN DELTA CITIES

2.1 What is climate change adaptation in Delta Cities?

Climate change adaptation is a process of adjustment to actual or expected climate change and its effects, leading to increased resilience of the city. Climate change adaptation typically addresses increased (or in some cases decreased) precipitation and temperature, extreme weather events, and sea-level rise, which are already being experienced due to global warming and, in most cases, are expected to become more severe. For cities, this often means managing flooding and water systems more generally, heat waves and urban heat island effect, and sea-level rise in coastal areas.

Cities in river deltas are often at the confluence of these impacts, facing a triple threat of challenging climate change effects. Perhaps as a result, delta cities are also some of the most advanced in terms of climate change adaptation and preparation and have good practices to share with peer cities around the world. Members of the C40 Connecting Delta Cities Network find it particularly valuable to share challenges and lessons learned, policy and infrastructure solutions, research and information, and to discuss technical and financial partnerships with one another in order to develop improved solutions for urban climate change adaptation.

2.2 Benefits of climate change adaptation in Delta Cities

Climate change adaptation is imperative to the continued longevity of most delta cities, particularly those whose economies rely on coastal infrastructure, such as port facilities. Climate change adaptation builds resilience to longer-term or future threats and risks, such as sea-level rise or temperature surges. Timely adaptation measures can help, for example, reduce future damages to or overload on urban infrastructure, avert emergencies such as freshwater shortages caused by groundwater salinisation, or prevent migration from flooded coastal zones.

Furthermore, adaptation measures also help address impacts that are already occurring and that will be exacerbated by climate change, such as storm surge, extreme rain events or heat waves. Coastal barriers, pumping and piping networks, water storage, and improved early warning systems can contribute to city's storm surge and heavy rain events readiness, helping to save lives, infrastructure and financial resources. For example, greenscaping can help lower extreme temperatures in cities and reduce adverse health effects and heat stress on urban infrastructure, while supporting urban biodiversity, promoting tourism and city liveability, and increasing carbon sinks.

Overall, a large body of research[i] shows that timely land-use planning and climate-proof city design measures are often significantly more cost-effective than future urgent, reactive and uncoordinated responses to sea level rise. A quantified illustration is provided by the City of Copenhagen, which put forward a Cloudburst Management Plan in 2012 with an estimated cost of proposed initiatives at DKK 3.8 billion (US$ 575 million). However, the city calculated the damage of a single cloudburst event (2011) at DKK 6 billion (US$900 million), demonstrating the cost-effectiveness of climate change adaptation measures. Finally, adaptation actions also deliver other economic co-benefits through energy efficiency improvements, job creation and green growth investments, for example.

2.3 Climate change adaptation solutions in Delta Cities

There are several hard- and soft-infrastructure technical solutions that are being pursued in many delta cities as part of their climate change adaptation measures. Some of the main ones are detailed below:

Pumping, piping and storage: Pumping, piping and storage infrastructure, along with improved drainage systems, are key adaptation technologies, protecting urban development from flooding during heavy rain events or local floods. These systems are especially important for delta cities, which might lie below sea level and need to manage water even outside of storm surge or flood events. A case in point is Jakarta[ii], which suffers from land subsidence and needs to pump water and wastewater up to natural watercourses that can then discharge it to the sea. Similarly, Hong Kong[iii] uses pumping, piping and storage systems to manage storm water and encourage rainwater harvesting in the city. Finally, Rotterdam[iv] and other Dutch Cities have been for centuries showcasing the use of pumps to drain polders (land areas below sea level drained for urban and agricultural use).

Sea walls and water barriers: Natural water barriers (coastal dunes, natural dykes) can be complemented by artificial permanent flood walls (dykes, levees and superlevees) and temporary storm surge barriers to prevent coastal or river flooding. The construction of permanent flood walls needs to take into consideration not only historical and current flood trends, but also future sea-level rise and higher frequency of extreme weather events related to climate change. Other stresses, such as droughts, can also weaken dyke structures. Additionally, flexible storm surge barriers require comprehensive cost-benefit analysis as well as desired protection level and efficacy studies, with the need to consider potential impact of a port closure on city’s economy.

Sea walls and water barriers’ technology has been successfully applied in many large cities around the world. Venice[v] has developed a flexible integrated system of storm-surge barriers (MOSE) to isolate the Venice lagoon from the sea during high-tide events, while allowing for continued port activity through a creative system of locks. Rotterdam and London, in addition to building and strengthening a network of permanent dykes and levees, built the flexible Maeslantkering and Thames barrier respectively to protect the cities from storm surges. Tokyo, for its part, built a series of super levees[vi] on riverbanks, which are not only strong, but also wider, more shallow-sloped levees (or dykes) that allow for urban development on top of the barriers as well as direct public access to riverside recreation areas.

Green-blue infrastructure: Green-blue infrastructure uses natural features (vegetation, soils, and natural ecosystem processes) to manage water and provide other environmental and community benefits. Green infrastructure, using plants and vegetation, not only has direct adaptation and greenhouse gas absorption benefits, but also provides numerous co-benefits. Green-Blue infrastructure helps reduce coastal risk by strengthening costal protective barriers (i.e. sand dunes and beaches), storing water (i.e. lakes and water basins), and providing a buffer between the sea and urban settlements (i.e. mangroves, wetlands). It can also help slow or store storm water runoff (i.e. green-blue corridors, bioswales, green rooftops), replenish groundwater tables (i.e. permeable green areas) and reduce the heat-island effect (i.e. parks and other green public areas).

A popular blue infrastructure feature used by a number of cities are the so-called "water plazas" – multipurpose areas that serve as public urban zones, sports parks or recreational areas during dry periods and as emergency water catchment system during heavy rain events. Examples include the Rotterdam "water plazas"[vii] and Copenhagen's Taasinge Square[viii]. Other green infrastructure elements are being incorporated into many cities' adaptation plans, i.e. New York Green Infrastructure Plan[ix], Greater New Orleans Urban Water Plan[x], Copenhagen St Kjeld's neighbourhood[xi], and Melbourne Streetscape improvements project[xii]. Hong Kong has also recently injected the concept of "revitalising water bodies" into their Policy Address[xiii], committing to strengthen the use of green-blue infrastructure in future developments.

Flood proofing: The primary objective of flood proofing is to reduce or avoid the impacts of flooding upon structures. There are two main types of flood proofing measures – wet or flood-resilient measures (allow floodwater to pass quickly through the structure to minimize structural damage, use flood-damage resistant materials and elevate important buildings); and dry or flood-resistant measures (make the building watertight to floodwater up to the expected height). In addition to property-level flood proofing, city-scale measures include installation of improved drainage, water plazas and underground storage, bioswales along the roads, green roofs and floating neighbourhoods, and insulation of key service systems, such as underground and other transport infrastructure.

These measures are particularly important for areas of delta cities that are situated outside of dykes or other water barriers and might be flooded during storm-water surge or due to rising sea levels. In the latter case, more structural adaptation measures are needed, including building elevation efforts. Cities that promote flood proofing include Rotterdam[xiv], Copenhagen[xv], and New York City[xvi]. Although flood proofing concerns mainly individual properties and is an area where the municipal government might have less direct control, it has high potential to reduce damages and costs, and can be addressed through strengthened building standards, raising awareness among homeowners and other educational activities.

Organisational approaches: In addition to the solutions outlined above, delta cities can consider the following suite of organisational or "soft infrastructure" approaches recommended to all cities undertaking climate change adaptation and longer-term resilience planning. These include: a) establish a central coordinating body responsible for addressing climate change and long-term planning to ensure a robust approach; b) mainstream and integrate adaptation and resilience planning across government agencies; c) promote awareness and engagement of the larger community (including residents and businesses) on climate change adaptation to promote risk awareness, inclusiveness, and a sense of shared responsibility; d) clearly identify, communicate and either incentivize or mandate non-government actors to share responsibility for adapting to climate change (i.e. private property owners and private sector); e) ensure flexibility of planning to reflect inherent uncertainties; and f) establish redundancy (i.e. create spare capacity and diversity within systems so that they can accommodate disruption and enable "safe failure" during sudden shocks).

3 GOOD PRACTICE APPROACHES TO ADAPTATION IN DELTA CITIES

3.1 Categories of best practice

Within the C40 Connecting Delta Cities Network, at least seven different but often complementary management approaches have been identified for developing sound climate change adaptation initiatives in a delta city context:

- **Take an integrated land use and water systems approach**
- **Engage community and other stakeholders in coastal and riverside land use planning**
- **Manage rainwater**
- **Manage groundwater table and land subsidence in relation to sea-level rise**
- **Consider the water balance: freshwater supply and source protection of rivers**
- **Adopt a multi-risk approach**
- **Utilise priority budgeting and creative financing for long-term security**

C40 has identified case studies from cities in the Connecting Delta Cities Network that highlight best practice in each of these categories.

3.2 City characteristics to consider during adaptation planning

The "*When/why a city might apply an approach like this*" sections linked to individual case studies below are designed to help cities assess if a given approach is suitable for them. There are key context indicators and city characteristics to be considered when adapting/designing any climate change adaptation measures. These can be divided into three main areas: governance and markets, capacity and external support.

First, governance structures and markets define the limits of action available to cities. These include powers that cities have over land-use planning and water-basin management, the infrastructure types and ownership structures in the city, as well as the market availability of urban climate change adaptation technologies and services. Certainly, cities can attempt modify these conditions, for instance through lobbying at the national level or creating public-private partnerships, but the results might be only felt in medium- or long- term.

Second, the level of leadership a city can exert depends on political powers as well as the financial and organisational capacity of the local government. Elements to consider include the amount of experience, capacity and resources within city government, the degree of long-term vs. short-term urban development planning, and the city's ability to mobilise finance for adaptation measures, either by funding directly or through partnerships.

Third, the ambition of city's climate change adaptation project should also reflect the degree of external support. Public interest and political will can help catalyse even very ambitious and innovative projects, in particular when external climate conditions and seasonal extremes (e.g. frequency of floods, storm surges, heat waves) increase awareness of the threats and risks. On the other hand, competing projects and priorities can make it more difficult to build support for climate change adaptation measures, especially under limited budget conditions. In that case, articulating the co-benefits of adaptation initiatives (economic returns, energy savings, health, comfort, etc.) can help ensure that the most important projects are prioritised.

3.3 Take an integrated land use and water systems approach

A comprehensive and synergistic view of urban climate change adaptation is particularly important given that there is not one quick-fix solution. Building and strengthening public infrastructures (e.g. dykes, levees, pumping and piping, sea-walls, water storage and blue-green corridors) need to be complemented by citizens' initiative in creating private green spaces to slow down water runoff and by personal behaviour changes (e.g. reducing illegal waste disposal that causes drainage clogging). It is particularly important to look at the entire city and its systems in relation to the natural topography and watercourses; plan for future risks, vulnerabilities and indirect impacts; and maintain consistency between emergency planning, integrated watershed management, financial plans, budgets and larger multi-year development or master plans. It is also crucial to seize climate change adaptation planning as an opportunity to strengthen the city's economy, improve the quality of life, and reap other co-benefits whenever possible.

Case Study: *Rotterdam*[xvii] *– Climate Change Adaptation Strategy*

Summary: Rotterdam, the largest European port, has an integrated climate change adaptation approach, marked by adoption of the Rotterdam Climate Proof[xviii] (2008) and the Rotterdam Climate Change Adaptation Strategy[xix] (2013). The strategy aims to: a) strengthen a robust system of flood, storm water surge and sea-level rise defences; b) adapt the urban space to combine its three functions: 'sponge' (water squares, infiltration zones and green spaces), protection (dykes and coastal protection) and damage control (evacuation routes, water-resistant buildings and floating structures); c) increase city resilience through integrated planning; d) foster the opportunities that climate change brings, such as strengthening the economy, improving the quality of life, and increasing biodiversity.

Results: Rotterdam's adaptation system is based on the flood and sea-level rise defence system, consisting of the Maeslantkering (flexible storm surge barrier), permanent sand dunes along the coast, and dykes along the rivers. In fact, Rotterdam adopts a tailored "inner-dyke/outer-dyke" approach. The inner-dyke city (mostly below sea level) is formed by a system of polders drained by water outlets and pumps and protected by smaller secondary dykes. The outer-dyke city area (3 - 5.5 m above the sea level), where about 40,000 citizens live, is vulnerable to rising sea levels or smaller temporary floods. It is being adapted through use of innovative technologies (e.g. floating buildings) and more traditional approaches (e.g. insulation of building facades and raising electrical installations). In addition to sea and river flood defence, Rotterdam is also addressing heavy rainfall threats. It has built water storage spaces, including the Museumpark car park underground water storage with capacity of 10,000 m^3, and is integrating Blue-Green Corridors into the urban landscape. These Blue-Green Corridors - watercourses and ponding areas - are designed to facilitate natural hydrological processes such as groundwater replenishment whilst minimizing urban flooding, enhancing biodiversity and improving cities liveability. Rotterdam also installed over 185,000 m^2 of green roofs in 2014 alone. Finally, the launch of the 100% climate-proof neighbourhood-scale project in the Zomerhofkwartier, demonstrates Rotterdam's commitment to comprehensive delta city adaptation.

Reasons for success: Since the very conception of the city, Rotterdam has a history of integrating land use and flood control, with city officials and other stakeholders making decisions around water management in relation to natural conditions. The city government also clearly identifies climate change adaptation as a priority, taking responsibility for resilient planning and financing a large portion of adaptation measures. Climate change adaptation investment needs have been integrated in the city budget, which enables the city to be proactive about planning for climate change resilience.

Case Study: *Ho Chi Minh City*[xx] *- Triple-A Strategic Planning*

Summary: Ho Chi Minh City (HCMC) is located in the delta area of the Saigon and Dong Nai rivers. The city's main challenge is urban flooding due to heavy rainfall and insufficient drainage capacity, exacerbated by fast urban development occurring on low-lying marshland, higher frequency of heavy rainfall events (attributed to the urban heat island effect) and projected or already occurring sea-level rise. HCMC also suffers from salinisation of the ground and groundwater. To address these multiple climate-change related impacts, HCMC adopted its comprehensive Climate Adaptation Strategy[xxi] in April 2013, within the 'Moving Towards the Sea with Climate Change Adaptation' project initiated in 2011 with assistance from Rotterdam. Based on the Triple-A Strategic Planning method (Assessment Atlas – Adaptation Strategy – Action Plan), the integrated Strategy consists of six directions: create smart urban density with connected living and working areas; develop step-by-step multi-scale flood protection measures; avoid local rainwater flooding by improving drainage and storage systems; reduce salinisation problems by relocating drinking water intakes upstream; and reduce land subsidence by restricting groundwater abstraction and improving surface water quality; reduce urban heat stress through developing the urban green-blue network.

Results: Currently in implementation, the Climate Adaptation Strategy divides the city into implementation zones, with on-going pilot projects in each. The pilot activities include the relocation of harbour infrastructure from the dense city area (District 4). This relocation opens space for climate adaptation measures -- including improvements in the urban landscape such as parks to provide stormwater attenuation -- towards the sea and onto low-lying areas (Nha Be District). These low-lying areas and the new harbour facilities on them are adapting flood proofing measures as they are located outside of planned dykes. The larger city-wide Strategy is being complemented by other measures, including: a mandate for all new developments to be elevated 2 - 2.5 m above mean sea level; a polder system to be built around the city with around 200 km of dykes and hundreds of tidal gates; and workshops on community based adaptation (early warning systems in communities and design of evacuation routes and drainage channels); in addition to on-going research by HCMC University on entire city modelling and simulations of probable flooding events.

Reasons for success: HCMC builds on experience and lessons-learned shared through cooperation with Rotterdam and through the C40 Connecting Delta Cities Network and tailors it to local geographical and political conditions. It also seizes climate change adaptation as an opportunity for new urban development and approaches the related land-use planning on a "whole-of-city" level, seeking synergies and complementarity between different re-development projects (e.g. District 4 – Nha Be district). HCMC also increases the Strategy's likelihood of success by first implementing pilot projects before scaling-up the measures.

When/why a city might apply an approach like this: A city might adopt this approach when the local administration is fully committed to addressing climate change and prepared to think "big picture" and long-term, and when there is significant political support to see implementation at a larger scale across the city. There is a great opportunity for a city to use this approach when it is developing or revising a land-use master plan/development plan or when hit by a climate-related event that has affected the city in many different areas.

3.4 Engage community and other stakeholders in coastal and riverside land use

One of the most obvious and most urgent requirements of good adaptation planning in a delta city is to assess how climate change will affect coastal and riverside areas. Many delta cities have significant port areas or otherwise use the coast for recreation, tourism or other economic generation. Similarly, riverbanks often serve multiple purposes, related to shipping, general transportation, real estate development, etc. These areas must be assessed for vulnerabilities that may put infrastructure or other uses at risk when facing sea-level rise, storm surge or fluvial flooding. The purpose and longevity of coastal or other low-lying infrastructure and land-use must be designed with climate resilience in mind as, in many cases, it defines the urban landscape into the next century and beyond.

Case Study: ***Jakarta***[xxii] ***- Socially Inclusive Climate Adaptation for Urban Revitalization Project***

Summary: Through the Spatial Plan 2030[xxiii], Jakarta Water Management Strategy 2030[xxiv] and Climate Adaptation Road Map for 2030[xxv], Jakarta aims to promote a safe and sustainable city. A key element is prevention or reduction of annual floods, which are caused by sea-level rise, storm surges and land subsidence, but also by insufficient flow and infiltration capacity of Jakarta's watercourses (due to illegal waste disposal clogging and insufficient blue-green networks). This is why Jakarta launched the Socially Inclusive Climate Adaptation for Urban Revitalization Project (USD1.3 billion to be invested over 2012-2017) that aims to relocate close to 400,000 illegal squatters from riverbanks and nearby reservoirs, within "a humanised and participative process". Jakarta already succeeded in implementing most of its pilot project around the Pluit Reservoir in North of Jakarta.

Results: As part of the pilot project, the Government of Jakarta has already built 14,201 new apartment units towards the target of 52,656 units by 2017 and relocated around 50,000 people to government subsidised high-rise, low-cost housing, while not only providing them with basic amenities (electricity, water), but also taking into account their job security through an economic empowerment scheme. This allowed Jakarta to expand and deepen the Pluit Reservoir to increase its water storage capacity and develop surrounding green spaces to improve water infiltration. The project also delivers multiple co-benefits, including improved livelihood and sanitary conditions for relocated citizens, carbon sequestration and urban pollution reduction. Finally, reduced flood frequency and duration coupled with fewer people living in flood-prone areas helps prevent disease outbreaks, such as malaria and typhus.

Reasons for success: Jakarta's success in addressing residents' initial opposition to the project stemmed from the community multi-stakeholder approach, with leadership from the Governor, officials, private sector and community heads, as well as intensive communication and public information campaigns. These had to address the issue of residents not being accustomed to living in rented vertical housing and reluctance to relocate without compensation, fuelled by lack of knowledge about new housing's benefits. Another reason for success was the private-public scheme, in which private companies holding property development permits in the affected area were obliged to participate in the project under a cross-subsidy scheme.

When/why a city might apply an approach like this: A city that faces competing interests for land use and other issues causing land encroachment, such as informal settlement, where buffer areas for flood protection are needed, could adopt an approach such as the one Jakarta took. All delta cities however, should assess their coastal and riverside land-use and determine if the uses are sustainable and resilient to changing climate conditions.

3.5 Manage rainwater

Managing rainwater to prevent pluvial flood is especially important in often low-lying delta cities, which generally have high water tables unable to drain or naturally manage rainfall. Typical traditional approaches to managing rainwater often involve expensive and extensive systems of drains, pipes and pumps that channel water away from the city. While these systems are in many cases necessary, delta cities are experimenting with other ways to manage water and look at green infrastructure and other means for slowing and absorbing rainwater to prevent damage and disruption.

Case Study: *Copenhagen*[xxvi] *- Cloudburst Management Plan*

Summary: Copenhagen, the capital of Denmark situated on the coast of the Øresunds region that connects the North Sea with the Baltic Sea, is vulnerable to sea level rise, warmer weather and more weather extremes in the future, including heavy rain events. Spurred by a series of highly damaging cloudburst events, including the July 2011 cloudburst that caused damages worth close to €1 billion, Copenhagen needed a better way to manage the water inundating the city during these downpours. In 2011 the City of Copenhagen adopted the Copenhagen Climate Adaptation Plan[xxvii], complemented by the Cloudburst Management Plan[xxviii] (2012) detailing the methods, priorities, and measures related to adaptation to extreme rainfall events.

Results: Copenhagen was able to work with water utility on a comprehensive restructuring of the Copenhagen drainage system (including separation of rainwater from waste water) and streetscape, in order to turn roads into rivers in the case of extreme rain (part of Copenhagen's "storm water plan") and direct water to outlets and retention basins. This is complemented by greenscaping, in particular through implementation of the Sustainable Urban Drainage System – building of green gardens, rooftops and bioswales to prevent rainwater from flowing directly into sewers.

Reasons for success: There are three main reasons for Copenhagen's success. First, the city had experienced repeated extreme weather events, which created political buy-in for change. Second, the Copenhagen government showed budget creativity by pushing for a change in national level legislation to allow the use of revenues from a water-use fee combined with private financing and revenues from taxes for investment in the water management system. Finally, presenting the adaptation measures under the "improved city green space" frame stimulated great enthusiasm and acceptance of major city infrastructure overhaul.

Case Study: *Hong Kong*[xxix] *- Stormwater Storage Scheme*

Summary: On average, Hong Kong is affected by about six tropical cyclones between April and October each year causing extremely heavy rainfall and their duration and strength is projected to increase with climate change. The annual average rainfall is about 2,400 mm and a record high rainfall intensity of 145 mm per hour was set in 2008. During these rainstorms, urban and rural low-lying areas and natural floodplains in the northern part of the territory face the risk of flooding, with rainwater management being complicated by the high speed of runoff due to the steep terrain in Hong Kong. The Drainage Services Department of the Government of the Hong Kong Special Administrative Region has been addressing the threats of heavy rainfall by expanding and improving the existing drainage, pumping and storage systems through detailed hydraulic analysis of different drainage basins in the Drainage Master Plan Studies.

Results: Upon the completion of these Studies between 1994 and 2010, Hong Kong constructed four storm water drainage tunnels to intercept the runoff at uphill catchments, built 27 village polders, 3 urban underground stormwater storage schemes, 360 km of trained (directed and slowed-down) river channels, and 2,400 km of drainage pipes for effective stormwater conveyance. The Happy Valley Underground Stormwater Storage Scheme, composed of storage tanks beneath several sports fields with a capacity of 60,000 m^3, is currently under construction. The first phase of the scheme was completed in early 2015 with half of its design capacity (30,000 m^3) commissioned. The above measures are complemented by sustainability and ecology considerations. Since last decade, Hong Kong has included greening and ecological enhancement in many of the river improvement works. The once channelized streams, such as Ho Chung River, Upper Lam Tsuen River and Kai Tak River, are gradually being revitalised into green rivers. More revitalisation projects such as Tsui Ping River and Yuen Long Nullah are under planning.

Reasons for success: With a population of 7 million and land area of around 1,100 km^2, Hong Kong is extremely compact with high potential negative impacts from flooding, which drives the prioritisation of adaptation measures by the local government, committed to protecting the city through holistic urban planning. Hong Kong's success in managing the flooding risks is attributed to the comprehensive Drainage Master Plan Studies (between 1994 – 2010), the subsequent Review Studies (since 2008) and continuous drainage infrastructure upgrade.

When/why a city might apply an approach like this: All cities need to understand the flow of water expected during major rainfall events and the natural water catchment areas. With urban infrastructure, these natural catchment areas can be augmented or re-routed as needed, based on land-use and vulnerable populations or infrastructure characteristics. In many cases, new rainwater management infrastructures can be multi-functional – as in the case of city roads in Copenhagen or the sports fields in Hong Kong. A city that is planning major infrastructure maintenance or overhaul has a particular opportunity to employ this approach.

3.6 Manage groundwater table and land subsidence in relation to sea-level rise

In delta cities, the ground is often soft and not static. In natural deltas, river flow will deposit sediment and effectively reinforce riverbanks. However, in delta cities, natural river delta sedimentation is inhibited by urban land use and land subsidence[xxx] (or sinking) occurs. This is further exacerbated by water being pumped out of the underlying water table, which might also cause drying of the usually moist soil, leading to surface infrastructure damage. Coupled with land subsidence, global sea-level rise increases the "relative sea-level rise" in delta cities (global sea-level rise + land sinking), which might also cause salinisation of groundwater aquifers. Saltwater infiltration of the aquifers might also increase water pressure on buildings' foundations, demanding new urban development be geared to future groundwater levels. Although it does not have acute impacts on delta cities, land subsidence needs to be taken into account during climate change adaptation and resilience planning. Different measures exist to slow subsidence that have other water management benefits, such as developing innovative street design with waterways and comprehensive storm water management to optimise the drainage and pumping system, slow surface runoff and maintain soil humidity.

Case Study: *New Orleans*[xxxi] *- Greater New Orleans Urban Water Plan*

Summary: New Orleans, lying on the coast of the Gulf of Mexico, suffers from increasingly frequent hurricanes (on average 11 per year and rising) with storm surges above 6 m high, land subsidence, and coastal erosion aggravated by sea-level rise. The ground in New Orleans has sunk as much as 10 feet (around 3.1 meter) over the past 100 years in some parts of the city, affecting streets, levee and floodwall integrity, and subsurface infrastructures. The land subsidence mainly impacts low-income households located in affected areas.

Results: In August 2015, New Orleans unveiled its Resilience Strategy[xxxii] with visions for 2050, which proposes 41 actions to build citywide resilience and address land subsidence. The Strategy proposes developing a comprehensive storm water management program (flood perimeter defence system, storm surge barrier, dykes and levees, restoring coastal wetlands), while aiming to mitigate land subsidence. Specific provisions for better management of subsidence threats are detailed in the Greater New Orleans Urban Water Plan[xxxiii] (2013), including: construction of circulating lowland canals; restoration and building of integrated wetlands; street design with bioswales and pervious pavement ("floating street") allowing groundwater table recharge; and building of blue-green networks. Blue-green networks (e.g. Lafitte Corridor) utilize vacant city lots that can serve to safely store storm water and help replenish the groundwater table, thus limiting the runoff of freshwater into the sea. Apart from land subsidence mitigation, New Orleans also envisages other adaptation measures such as reducing above-surface utility systems and improving the subsurface ones. Finally, further research on soils infiltration and advanced groundwater monitoring is being carried out. Overall, New Orleans estimates that integrated water management could save property owners up to US$2.2 billion in subsidence-related maintenance costs over the next 50 years.

Reasons for success: New Orleans has been able to undertake a holistic, comprehensive redesign of its water management after Hurricane Katrina revealed vulnerabilities of the previous system ten years ago. Since then, New Orleans has received the attention and assistance from the national government, the state government, and many non-government actors, researchers and philanthropies. New Orleans has therefore been able to serve as a model project for delta cities and has been able to reassess its relation to water from four directions –the sea, the river, the rain and the ground.

Case Study: ***Jakarta*[xxxiv] *- Jakarta Coastal Defence Strategy and Flood Mapping***

Summary: Jakarta, located in a lowland delta area with close to 50% below regional water level, is vulnerable to coastal and river flooding due to monsoons, sea-level rise and insufficient and faulty drainage infrastructure. The rapid rates of land subsidence play a key role in relative sea-level rise: estimates suggest an average subsidence rate of 40 mm/year, in some places up to 20 cm/year. An estimated 90% of North Jakarta is expected to lie below sea level in 2030 and the 13 rivers and canals of Jakarta are projected to stop flowing freely to the sea around 2025 if no measures are taken. As the sea-level rises, saltwater intrusion of groundwater tables also becomes a problem. This is related to the high volume of groundwater extraction, with additional pressure from construction and natural consolidation of sedimentary layers. Greater Jakarta has prepared a policy for disaster management as well as the Jakarta Coastal Defence Strategy and Flood Mapping[xxxv]. Jakarta is also preparing a Sea Defence Wall Master Plan to protect the Northern Jakarta from inundation caused by increase in sea level and land subsidence and is now pursuing the development of a larger adaptation strategy.

Results: A set of measures are planned to minimize land subsidence, including limiting groundwater extraction, providing sufficient supply of raw water from surface water, developing water retention basins, and building absorption wells called *biopores* (1 million planned). The restriction on groundwater extraction, decreed by regional regulation, is a key measure for slowing down land subsidence. The Northern Jakarta area is mandated to have 100% water-supply coverage and 0% groundwater abstraction by 2015. The rest of the city will also see groundwater extraction phased out in geographic bands moving southward by 2020, 2025 and 2030, with the similar assumption that piped water will be provided in all districts by 2030. This initiative is co-financed by taxing groundwater consumption and is supported by development of alternate water supply piping for large industrial users or relocation of large groundwater users outside the 'critical zones', but it admittedly still faces some challenges of proper enforcement. Other initiatives include construction of East Flood Canal and interconnection canals; Jakarta Emergency Dredging Initiative[xxxvi] of vital waterways (currently at 30% capacity partly due to clogging by high volume of improperly disposed solid waste); reconstruction of pumps; protection of natural coastal defences (mangroves); construction of sea embankments; and resettlement of illegal housing along rivers and lakes.

Reasons for success: Jakarta's mitigation of land subsidence is driven by international assistance and sharing of lessons learned with other delta cities, as well as acknowledgment of the need for an integral water management approach, in which sanitation, wastewater treatment, surface water quality, alternate access to clean drinking water and flood protection are being improved in an interconnected way.

When/why a city might apply an approach like this: This approach is particularly relevant if a city has a significant portion of land at, or already below, sea level, is highly canalized, or has high rate of groundwater extraction and the delta is no longer naturally being reinforced with sediment.

3.7 Consider the water balance: freshwater supply and source protection of rivers

Though delta cities often first think about addressing flooding (from the sea and rivers), they are usually also vulnerable to freshwater scarcity. As global warming changes climates around the world, delta cities are becoming more prone to heat, droughts and water scarcity either within their jurisdictional boundaries or further up their watersheds. Groundwater salinisation and general population pressures compound this risk.

Case Study: *London*[xxxvii] *- Optimised portfolio of water supply options*

Summary: London, built astride the River Thames and under the tidal influence of the North Sea, is expected to keep growing from the present day population of 8.6 million to 10 million by 2031[xxxviii]. It is located in the most populated and driest part of the United Kingdom – an area classified by the UK Environment Agency as being 'severely' water stressed. One of the city's main concerns is maintaining a secure and sustainable supply of fresh water, especially as Thames Water, the main water utility for London, estimates that without action, demand for water will exceed supply by 213 million litres of water per day by 2025[xxxix]. This deficit reflects a combination of the expected increasing demand for water from a growing population, the projected decreasing availability of rainfall in warmer, drier summers due to climate change, and need to integrate the European legislative requirement to protect unsustainable water abstractions. The city government is working closely with Thames Water on a twin-track programme to balance supply and demand for water through improving the water efficiency of existing properties while seeking new climate-resilient water resources.

Results: The aim of achieving greater water security will be met through a combination of actions. Firstly by reducing the demand for water through fixing leaks in the main water distribution networks, ensuring new development is water efficient, and implementing an integrated programme of retrofitting water efficient devices, installing smart water meters and raising awareness of the financial and environmental benefits of being more water efficient to encourage behaviour change among consumers. In parallel, Thames Water is working to understand the resilience of new water supply options to long-term future challenges. This involves modelling how well individual and combinations of water supply options (for example a new reservoir, desalination, etc.) respond to future challenges despite deep uncertainties about the impact of climate change, energy costs, population growth, etc. The aim is to develop an optimised portfolio of water supply options that provides the greatest resilience and environmental benefits for the best value.

Reasons for success: London recognised the economic and environmental benefits of saving water resources and implemented its household water efficiency retrofits based on a detailed cost-benefit analysis. The city also explores partnerships with a number of stakeholders, from water utility to energy efficiency service providers, to help share the efficiency retrofits' cost.

Case Study: *Singapore*[xl] *- Marina Barrage*

Summary: With population density of over 7,700 inhabitants per km^2 and limited water resources, Singapore's water resource management is a huge challenge. In the 1960s and 1970s, Singapore faced the problems of polluted rivers, water shortages and widespread flooding. Over the last 50 years, PUB, Singapore's national water agency has developed a diversified water supply through the Four National Taps, namely water from local catchments, imported water, NEWater and desalinated water. These make up the long-term strategy that ensures a sustainable supply of water for Singapore. Today, two-thirds of Singapore's land area is water catchment, and rainwater is collected and stored in 17 reservoirs around the island. One of these is Marina Reservoir, which is a reservoir in the city that was the vision of Singapore's first Prime Minister Lee Kuan Yew more than two decades ago. It was created by building the Marina Barrage[xli] across the 350m wide Marina Channel. With the largest and most urbanised catchment at 10,000 hectares, the reservoir collects water from some of the oldest, most densely built-up areas of Singapore and its Central Business District.

Results: With three functions fused into one facility, the Marina Barrage exemplifies PUB's long-term planning and integrated water management approach. First, it helps secure water supply. With the creation of Marina Reservoir and two other reservoirs, Punggol and Serangoon, Singapore's water catchment areas increased from half to two-thirds of Singapore's land areas in 2011. Advancements in membrane technology have allowed Singapore to treat water collected in urban catchments to well within World Health Organization (WHO) drinking water standards. Second**,** Marina Barrage is part of a comprehensive flood control scheme to alleviate flooding in the low-lying areas of the city, such as Chinatown and Boat Quay. During heavy rain, the series of nine crest gates at the dam will be activated to release excess storm water into the sea when the tide is low. In the case of high tide, 7 giant pumps, each capable of pumping an Olympics-size swimming pool per minute, will drain excess storm water into the sea. Third, as the water in the Marina Basin is unaffected by the tides, its water level can be kept relatively constant all year round. This makes it an ideal lifestyle destination for water-based recreational activities such as sailing, kayaking and dragon-boating. With a view of the city skyline, the iconic grass turf roof provides a unique space for a variety of land-based community activities.

Since its opening, the Marina Barrage has received more than 10 million visitors and hosts more than 1,800 local and international events, including the National Day celebrations and New Year's Eve Countdown Party. The Marina Reservoir was also the venue for the rowing and canoeing competitions of the 2010 Youth Olympic Games and also five sports competitions of the 28th South East Asian Games held in June 2015.

Reasons for success: The creation of Marina Reservoir was made possible by a 10-year massive clean-up of the Singapore River and Kallang River from 1977 to 1987, which was a result of the integrated planning and close coordination between various ministries and agencies led by the then Ministry of the Environment. Singapore adopts a holistic approach to managing its water resources, essentially overseeing the entire hydrologic cycle through one national water agency, PUB. The approach of "closing the water loop" allows Singapore to develop a diversified water supply through the Four National Taps strategy and has enabled the government to deliver an efficient, safe and sustainable water supply. The Marina Barrage is an example of an infrastructure that serves dual objectives of increasing water supply and flood control.

When/why a city might apply an approach like this: A city might choose this approach if it has either a growing population, a diminishing or otherwise unstable water supply, or both. A city should consider this type of approach if it is facing warmer conditions or possibly drought in the city itself or elsewhere in its watershed/water sourcing system.

3.8 Adopt a multi-risk approach

As we have noted previously, climate change adaptation must be prioritized and addressed alongside other risks a city may face, such as earthquakes or volcanic activity. In some cases, the solutions can be "no-regret" or "win-win" because they address a number of different risks at once.

Case Study: *Tokyo*[xlii] *- Super levees*

Summary: The City of Tokyo lies largely below the flood level of its three main rivers, has high annual rainfall and is vulnerable to storm surges, earthquakes and tsunamis. Climate change is projected to increase peak river discharge and frequencies (peak discharge currently up to 100 times higher compared to minimum discharge), raise high tide and increase typhoon size, and exacerbate the impacts of potential earthquakes and tsunamis due to higher sea level. Thus, extreme floods are expected to occur more frequently in the future. To respond to the multitude of risks, Tokyo has developed the concept of a super levee.

Results: A super levee is a robust broad river embankment resistant to overflow, seepage and even earthquakes, thanks to special seismic reinforcement. It mainly differs from a conventional dyke by its width (a 10 m high super levee will be about 300 m wide). Super levees are well suited for dense urban areas, allowing for urban development on its top, integrating multifunctional structures and, compared to traditional levees, allowing easy access to rivers and reconnection with urban water ecosystems. For instance, the super levee built along Tokyo's Ara River combines a broad dyke with a park and a small high-rise, whereas the Sumida River super levee combines a broad dyke/flood-wall with a promenade and a large high-rise.

Reasons for success: Tokyo's multi-risk approach success builds on a long history of experience with coastal and river flooding defences and detailed risk-assessment with wide margins, strengthened especially after the March 2011 earthquake and tsunami flooding.

Case Study: *London*[xliii] *- Thames Estuary 2100 Plan*

Summary: London already benefits from world-class tidal flood defences. However, increasing pressures, including climate change, means that flood risk is increasing. The Thames Barrier and associated tidal defences currently protect 1.25 million people and £200 billion worth of property. There is significant development being planned behind these defences and a wealth of commercial opportunity, which requires continued investment in this critical flood defence infrastructure not only in the short-term but the long-term too. In response to a changing estuary and the risk associated with this, the Environment Agency produced the Thames Estuary 2100 Plan (TE2100), which sets out how to manage flood risk across the estuary, up to the end of the century.

Results: As climate change is a significant factor in determining increases in flood risk, the Environment Agency funded major new research into this, looking at changes to fluvial flows, sea storm surges and sea level rise due to thermal expansion and polar ice melt. In total, the modelling took up one year's capacity of the Met Office supercomputer. Key findings were: storm surge tides on the Thames are less likely than previously thought to increase in either height or number, due to climate change, over the next 100 years; fluvial flood flows on the river Thames could rise by about 40% by 2080, driven by increased rainfall; sea levels could rise by up to 88 cm by the end of the century, and greater increases are feasible.

The plan is a flexible and adaptable solution to increasing flood risk in London and the Thames estuary. It avoids committing to flood defence infrastructure which may either prove unnecessary, due to lower than predicted sea-level rise, or be made quickly redundant, by accelerations in climate change impacts. This innovative approach to 'planning for uncertainty', allows for flood risk management measures to be developed in a timely, sustainable and cost-effective way, whatever the future holds.

The TE2100 plan has also driven much of the science behind the latest marine climate projections for London and the UK. Its approach has gained interest from around the world, in cities such as New York, Rotterdam, Jakarta and others, to pioneer new approaches to climate change adaptation.

Reasons for success: Although at the forefront of delta city climate change adaptation, London has recognised the need to re-evaluate its data and scenarios based on changing climate and other external conditions to keep up-to-date with new potential risks and opportunities.

When/why a city might apply an approach like this: This practice is applicable to cities that face a combination of a number of concurring serious geophysical risks or that need to re-asses the risks and defence opportunities to keep up to date with changing climate and urban conditions. The super levee solution is also particularly suited for cities with large portions of wide riverbank area for redevelopment.

3.9 Utilise priority budgeting and creative financing for long-term security

A final good practice principle is the ability to pursue creative financing to address climate impacts. Many adaptation solutions do not necessarily pay for themselves within a set payback period and financial returns are difficult to calculate given the uncertainty and unpredictability of major climate events and disasters. As a result, climate change adaptation is often the responsibility of the government. However, with tight administrative budgets and high maintenance and operations costs, cities are undertaking creative budget prioritisation and exploring innovative solutions to finance adaptation.

Case Study: *New York*[xliv] *- Mitigation banking program*

Summary: New York City (NYC), situated in the delta of the Hudson River, is prone to storm flooding and sea-level rise that is exacerbated by the loss and degradation of its wetlands, which provide natural absorptive and flood defence capacity. A case in point is the Saw Mill Creek marsh, a severely degraded wetland on Staten Island's west shore, which could have provided the absorptive capacity to mitigate much of the severe flooding that occurred during Hurricane Sandy in 2012. After the Hurricane, NYC lacked a sustainable funding source that it could draw on to restore this and many other degraded wetlands throughout the City. Healthy wetlands are needed to provide a resiliency buffer for coastline communities, many of which are disproportionately lower income than communities across the city at large. To address these issues, NYC introduced MARSHES, a citywide wetland mitigation banking program, which utilises one-time Federal recovery funding to perpetuate a sustainable and replicable program for wetland restoration and resiliency improvements across the city.

Results: Mitigation banking addresses the sub-optimal and ad-hoc current system of mitigation by developers in New York that are seeking to build on or near wetland and aquatic resources. This ad-hoc system requires developers to negotiate with resource agencies to find, restore or create aquatic resources in-kind. This requirement often results in wetland restorations that are less cost-effective, efficient and environmentally desirable. Through mitigation banking programs, a third-party entity performs wetland restoration in offsite, environmentally significant areas, thus generating "mitigation credits" that are sold to developers to offset the impacts of their activities. Such an approach typically enables the protection of more and more critical wetlands, thereby producing both economies of scale by reducing the cost associated with mitigation, as well as ecologies of scale by restoring larger, more ecologically diverse, and integrated wetland habitats.

In the case of Saw Mill Creek marsh, the US$16.73 million publicly financed restoration project will result in a triple bottom line by providing a resiliency buffer to protect the adjacent communities against the impacts of storm-related flooding, easing the burden of permitting for resilient construction activities taking place along the waterfront, and also generating mitigation credits to help finance the project itself and catalyse future wetland restorations elsewhere in the city.

Reasons for success: New York City was able to leverage Federal disaster recovery funds to help seed the initial mitigation bank. Mitigation banking is a model already tested throughout the U.S. to balance economic initiatives with wetlands restoration. However, this effort had never before been pursued with Federal recovery funding and is rarely undertaken by a public agency to self-finance its own mitigation effort. This model will also allow the city to plan for and finance the long-term stewardship of the marshes and wetlands that will be rehabilitated.

Case Study: *Melbourne*[xlv] *- Coastal Adaptation Pathways Project*

Summary: The City of Melbourne adopted its Adaptation Strategy in 2009 to address different climate change related risks, from warmer temperatures, heat waves and lower rainfall, to seasonal intense storm events and flash flooding. Climate change is predicted to increase the frequency and intensity of flood and extreme storm events. A number of areas in Melbourne have existing vulnerability to these types of events and the threat will likely be exacerbated in the future. However, the first step on the adaptation pathway was to understand and prioritize the risks and responses, based on a complete cost-benefit analysis. This approach helps to target limited resources to most needed adaptation actions.

Results: The City of Melbourne's understanding of the risks and economic impacts of climate change to coastal areas has been boosted by the government-funded Port Phillip Bay Coastal Adaptation Pathways Project. This tool aims to assist climate adaptation decision-making in local flood prone areas by proposing an economic framework for decision-makers to compare the value communities place on occupying land subject to flooding, the cost associated with flood events and flood mitigation measures. This improves decision-makers' ability to decide on the type and timing of flood mitigation measures. The project also produced five detailed case studies of impacted sites, two of which, Southbank and Arden-Macaulay, sit within the Melbourne municipality. Such an economic model framework can also be shared among cities and prevent the need for each of the bodies to develop their own models. Moving forward, the City of Melbourne is further developing the framework into an Integrated Climate Adaptation Model, addressing both water and heat and looking at increasing community participation in all aspects of adaptation planning, much as they engage citizens in participatory budgeting in Melbourne.

Reasons for success: This project focused on developing stronger partnerships between the responsible authorities. Councils, State Government agencies and State Government departments have each learned about how to work efficiently together in the future and though limitations in the research and methodology were identified, Melbourne and the other partners emerged with a framework for inter-regional decision-making in climate change adaptation.

Case Study: *Copenhagen*[xlvi] *- Public-private finance scheme*

Summary: The City of Copenhagen has adopted an innovative public-private finance scheme to fund its Cloudburst Management Plan for storm water management. In particular, it had to address ambiguous responsibility allocation for greenscaping (construction of bioswales, green retention basins, etc.).

Results: The main stormwater runoff infrastructure (underground storage, drainage system) is financed through collected water charges by publicly owned water utility companies, with fees controlled and regulated by the local government. The greening component linked to improvement of public space is paid for by the local government, primarily through collected taxes, but new sources of finance might become available as Copenhagen is also lobbying the national government for a change in legislation. The remaining challenge is the finance of adaptation measures in privately owned buildings, which have the biggest potential to reduce damages from storm flooding (about one-third of costs estimated by the Cloudburst Plan) but few incentives beyond higher insurance prices.

Reasons for success: Holistic stakeholder engagement is one of the main drivers of the successful planning and implementation of the Cloudburst Management Plan. Copenhagen was able to collaborate successfully with their national government to change legislation allowing for a wider application of water fees, while also working with the Danish water utility to coordinate government and water services. Copenhagen also worked with various private-sector partners, including insurance companies, to monetise losses and projected losses and create cost-benefit analyses of various measures in order to provide a strong rationale for significant budgetary allocation.

When/why a city might apply an approach like this: Cities around the world should in particular consider priority budgeting, adaptation pathways and creative finance when a complete climate change adaptation plan's financial needs are larger than the amount available within the city budget and other funding sources are limited or lacking.

4 FURTHER READING

The Connecting Delta Cities Network has published a series of good practice books on the successful approaches the cities have employed over the years. This guide draws upon some of the most important and latest findings of the CDC group.

- Coastal Cities, Flood Risk Management and Adaptation to Climate Change – CDC Book Volume 1. Available at: https://www.c40exchange.org/download/attachments/28770375/Connecting%20Delta%20Cities%20Book%201?version=1&modificationDate=1378801189711&api=v2
- Sharing Knowledge and Working on Adaptation to Climate Change – CDC Book Volume 2. Available at: https://www.c40exchange.org/download/attachments/28770376/Connecting%20Delta%20Cities%20Book%202?version=1&modificationDate=1378801201683&api=v2
- Resilient Cities and Climate Adaptation Strategies – CDC Book Volume 3. Available at: http://www.deltacities.com/documents/CDC_volume_3_Resilient_Cities_and_Climate_Adaptation_Strategies.pdf
- Connecting Delta Cities – a C40 Cities Network Website. Available at: http://www.deltacities.com

A number of external organisations, including C40 partners, have published best practice guidance on delta cities-related areas including:

- Sinking Cities – An Integrated Approach Towards Solutions. Available at: http://waterlandexperts.nl/wp-content/uploads/2014/09/Land-Subsidence-Vision-document-Sinking-Cities-Deltares.pdf
- Protecting Our Capital: How climate adaptation in cities creates a resilient place for business. Available at: https://www.cdp.net/CDPResults/CDP-global-cities-report-2014.pdf

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