City of London Adaptive Pathways Study

City of London Climate Adaptation and Resilience Planning

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CITY OF LONDON

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Executive Summary

Purpose and call to action

This report contains the outcomes of the City of London Corporation Adaptive Pathways study. This considers long-term climate resilience challenges facing the City of London area (the 'Square Mile') and the wider portfolio of City Corporation assets from now to 2050, and beyond. The work seeks to build off the progress made under existing local, regional and national resilience initiatives, to harness the current public momentum for climate action and to align with wider studies commissioned by the City Corporation to inform the development of the Climate Action Strategy.

Shaping climate resilient environments, where people and businesses can thrive for generations to come, is considered central to the Climate Action Strategy. The City Corporation as such have commissioned this study to help inform the selection of climate resilience and climate adaptation measures that may be adopted within the Climate Action Strategy for 2020 onwards, seeking to act swiftly in recognition of the human, environmental and economic imperatives for accelerating climate adaptation and resilience action.

Climate Risk Assessment

A climate risk assessment has been carried out for the Square Mile. As part of this, an analysis of the Met Office Climate Projections (2018) for the Square Mile was undertaken. This indicated several key climatic trends facing the area:

- Warmer and drier summers – under a high emissions scenario the Square Mile could see summer temperatures increasing by nearly 5°C by 2080, with rainfall decreasing by about a third compared to weather in 1981-2000.
- Milder and wetter winters – while snowfall in 2080 may be less than a third of the levels in 1981-2000 under a high emissions pathway, rainfall could increase by around 20%, with temperatures rising around 3°C.
- Heatwaves and droughts – higher temperature summers combined with less rainfall could dramatically increase the frequency and intensity of droughts and heatwaves in future decades. By 2080 we may see four times the duration of heatwave compared with today, and by 2050 droughts twice as long as those experienced today.
- Wind speeds and thermal comfort – wind speeds are not likely to increase beyond the current natural level of variability we see today. Similarly, while temperatures are set to increase, levels of relative humidity are set to decrease. This decrease in relative humidity may help offset the negative impacts for thermal comfort caused by warmer weather.

The risk assessment then focuses on the 'top six areas of inter-related climate change risks for the UK' as identified by the UK Climate Risk Assessment 2017. It is these risks that the Adaptive Pathways study looks to mitigate and alleviate with particular reference to the Square Mile and City Corporation's assets:

1. Flooding and coastal change risks to communities, businesses and infrastructure;
2. Risks to health, well-being and productivity from high temperatures;
3. Risk of shortages in the public water supply, and for agriculture, energy generation and industry;
4. Risks to natural capital, including terrestrial, coastal, marine and freshwater ecosystems, soils and biodiversity;
5. Risks to domestic and international food production and trade; and
6. New and emerging pests and diseases, and invasive non-native species, affecting people, plants and animals.

This analysis of the Met Office Climate Projections (UKCP18) was supplemented by research into each of these risks in the context of the Square Mile and the City Corporation's assets across London. A summary of findings is listed in Table 1-1 – in all cases the risks were found to be pressing, largely due to the diversity of occupants and users of these spaces, the scale and importance of the green spaces run by the City Corporation and its dependence on international trade.

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Adaptive Pathways: Approach

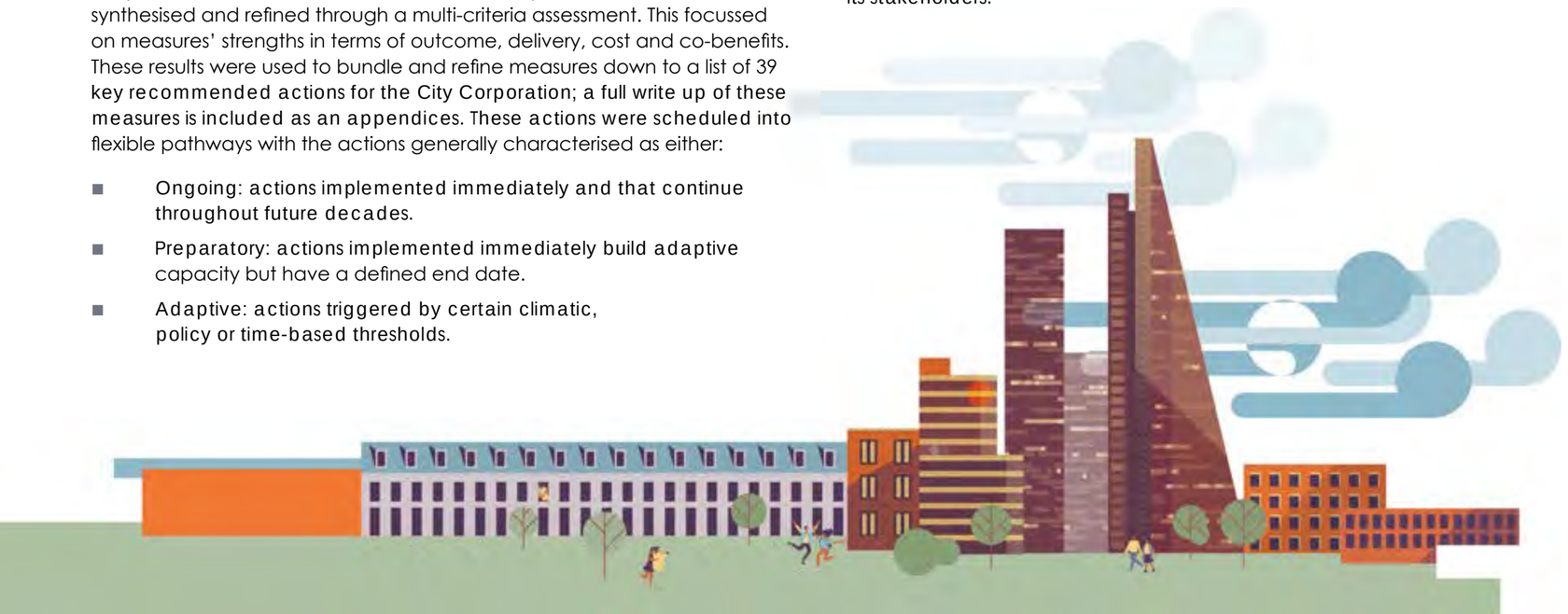
The purpose of the Adaptive Pathways is to develop a risk-based approach to climate adaptation and resilience, building off the Climate Risk Assessment to identify thresholds and trigger points by which actions must be taken to ensure that the City Corporation and the Square Mile remains resilient to the impacts of climate change. This is a dynamic, living approach that facilitates short-term action and establishes a guiding framework to ensure the City Corporation remains responsive and resilient over the longer term.

Following stakeholder engagement and the Climate Risk Assessment, a longlist of possible actions to build resilience of the Square Mile and City Corporation assets across London was drawn up. These were then assessed, synthesised and refined through a multi-criteria assessment. This focussed on measures' strengths in terms of outcome, delivery, cost and co-benefits. These results were used to bundle and refine measures down to a list of 39 key recommended actions for the City Corporation; a full write up of these measures is included as an appendices. These actions were scheduled into flexible pathways with the actions generally characterised as either:

- Ongoing: actions implemented immediately and that continue throughout future decades.
- Preparatory: actions implemented immediately build adaptive capacity but have a defined end date.
- Adaptive: actions triggered by certain climatic, policy or time-based thresholds.

Adaptive Pathways: Insights

A summary of the key actions for each risk is provided in Table 1- 1. These distinctions largely relate to the degree to which major physical interventions are required to tackle the risk, and how much work has been undertaken to date. Actions around some risks – namely flooding and water stress – may need to involve major infrastructural interventions, with thresholds linked to wider management decisions from external bodies. In contrast, the City Corporation will have more direct influence over management of overheating and its natural capital. For risks where trends will be less easy to control and predict – such as those associated with food supplies and from pests and diseases – the City Corporation will have a key role in coordinating research, guidance and support packages for its stakeholders.



Adaptive Pathways: Funding strategies and implementation

Delivering the strategy comes with significant costs to the City Corporation over the short, medium and longer term. Acting now however is vital to avoiding higher future costs that may be incurred through not keep pacing with the level of change. A high-level costing exercise has been undertaken and this anticipates that a total programme cost of £ 904 million and £1 billion between 2020 and 2048. The City Corporation are already taking action to adapt and build resilience to climate change. As such, it is believed that a proportion of this cost can be delivered through existing budgets and expenditures typically already incurred by the City Corporation. When accounted for, the high-level analysis suggests an additional investment of between £509 million and £621 million may be required across the whole programme life cycle 2020-2048.

Proposals have been made for how a funding strategy to finance actions proposed within this strategy may be structured. This advocates for establishing a dedicated coordinated Climate Action Fund that draws on funds from existing sources within the City Corporation and blends these with additional funds secured from external sources. Establishing a dedicated Climate Action Fund will help to ensure that investment for climate action is safeguarded and that committed funds can be used in the most effective way. It will further enable funds to be managed for multi-year programmes and allow the City Corporation to deal with and plan for uncertainties. The funding strategy is based around four key programmes: a climate readiness program, a mainstreaming climate action program, a capital project program and a strategic partnerships program.

The adaptive pathway methodology requires a shift from a static risk management approach to a more dynamic approach, one which responds to the inherent uncertainty around climate impacts. This shift to a dynamic strategy may require new approaches to programme management; an outline governance structure for climate resilience and adaptation action is proposed within this document.

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Risk	Key Impacts	Summary of Pathway	Key Thresholds
1 – Flooding and coastal change risks to communities, businesses and infrastructure	Surface water flooding, flooding from the Thames and groundwater floods are all risks in the Square Mile, and could affect hundreds of properties, organisations and critical infrastructure if unmanaged.	Flood risk management will be continued in a similar manner to today, with maintenance of assets, flood modelling studies and planning regulations scaled on a rolling basis alongside new funds to support installation of property-level defence measures for vulnerable populations. Accelerated implementation of Sustainable Drainage Systems SuDS should begin now. In future it may be necessary to more radically alter flood management practices depending on iterations of the TE2100 plan; decisions regarding this are expected around 2050.	A decision regarding a new Thames Barrier (anticipated 2050) will be a key point at which a new approach may be preferred.
2 – Risks to health, well-being and productivity from high temperatures	Rising temperatures and heatwave intensity across the region could have severe health implications, increase heat-related mortality, put strain on health services and infrastructure functionality, as well as have negative consequences for wellbeing associated with recreational use open spaces, disease and pathogen transmission and air pollution levels.	Measures with regard to managing overheating will need to deliver inclusive action and protect the health of vulnerable populations who may be disproportionately affected by the impacts of overheating. Many measures to tackle overheating should be implemented in line with temperature rises experienced and projected in the coming decades. Based on the defined thresholds, it is recommended that action to retrofit properties starts immediately, a cool streets programme may be triggered in the next five years, while action to diversify energy sources due to heat-related disruption may not be required until around 2060.	As temperatures rise the City Corporation may wish to incrementally initiate new actions. Max daily temperatures may exceed 36oC in 2050, high heat stress for humans, and reach 40oC by 2080 – which may cause power station shut-down.
3 – Risk of shortages in the public water supply, and for agriculture, energy generation and industry	Without action, demand for water could be more than 150% of the available resource in many catchments across the UK in future decades. Droughts may bring acute periods of water stress, with knock-on disruption to energy generation and industry, and further risks surrounding public health, infrastructure and food supplies.	Immediate actions to tackle water stress include planning, research and monitoring to better understand water systems and usage in the Square Mile. Water conservation measures should be implemented now and monitored wherever possible. These actions will then inform more substantial measures, which could include leak reduction programmes, diversification of energy supplies and climate-resilient planting in open spaces.	Water stress is an immediate risk. Changes to the UK energy mix and Thames Water management strategies in coming decades will also be crucial determinants of future levels of risk

Table 1-1 Summary of key risks and proposed actions

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Risk	Key Impacts	Summary of Pathway	Key Thresholds
4 – Risks to natural capital, including terrestrial, coastal, marine and freshwater ecosystems, soils and biodiversity	Climatic changes fundamentally alter natural trends and ecosystems, which can impact the natural systems which we depend on for goods and services, as well as causing decline and loss within ecosystems themselves. The City Corporation manages over 4,500 hectares of green space in and outside the Square Mile, including large Sites of Special Scientific Interest, habitats for important urban species, ponds and reservoirs.	Natural Capital is the risk with the most actions proposed. In addition to accelerating actions to increase green space through SUDs, for example, identifying growing opportunities and setting up programmes to better support community planting initiatives, a key short-term focus of the pathway is building on existing data collection, reporting and research efforts. These efforts will be vital in being able to robustly understand the impacts of climate change on natural capital assets in the future, and in turn informing the most effective course of action. Adaptive measures around such as increasing green space cover will likely be required in the short term while measures such as climate-resilient planting may not be necessitated for a number of years.	A key threshold is the Defra 25y plan 2043 deadline, which concerns numerous targets for natural capital management. In terms of land adaptation and climate resilience planning, by 2071 high temperatures may see Britain approach a 'Mediterranean' climate.
5 – Risks to domestic and international food production and trade	A consequence of many of the previous risks in this study has been disruptions to food supplies. Since 40% of food in the UK is imported, food infrastructure is vulnerable to national and international shocks and stresses, which may include weather-related shifts in agricultural production, geopolitical crises and events, ,disruption to the City Corporation's wholesale food markets, legislation gaps and volatile food prices.	Measures to build resilience of food infrastructure in the Square Mile and City Corporation assets reflect the City Corporation's combined roles as a port health authority, owner and manager of London's wholesale food markets, asset owner and local authority. Tackling food poverty is proposed as a key ongoing action for investment. This may be supported by a key co-benefit action to incorporate into better management of food waste, modelling of supply chains and regional growing schemes but given the systemic nature of the risk, an overarching programme to tackle food poverty is viewed as key. Operational resilience planning of ports and markets will be vital given the role of these in London's food supply chain network.	Thresholds for food infrastructure are poorly understood, so the City Corporation should invest in research on their food supply chains to inform resilience planning in this area.
6 – New and emerging pests and diseases, and invasive non-native species, affecting people, plants and animals	Milder, wetter winters and warmer summers would significantly raise the threat of pests and diseases in the UK, with these conditions facilitating the spread and emergence of vectors like ticks, mosquitos and rats, and increase both transmission rates and overwinter survival rates.	The City Corporation will take action to support grassroots groups (mutual aid) and strengthen healthcare programmes, while also undertaking regular horizon-scanning exercises and research programmes to better understand the risk landscape. Alongside this, measures around water management and natural capital control will be designed to incorporate an understanding of risks from pests and diseases – for example strengthening the natural capital planning strategy must take place with budgeting and immediate activities planned to combat pest outbreaks and to support vulnerable species.	Pests and disease rates are already rising, with transmission and spread set to increase with temperatures. Key thresholds may come with rising heat stress and increasingly hostile planting conditions, as these will make people and wildlife poorly equipped to combat diseases.

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Next Steps

Action to build resilience and adaptive capacity will require multi-agency working and cross departmental coordination. It is recommended as such that the City Corporation develop a clear 'partnership engagement strategy' for key external partners. Internally, the proposed governance structure may be characterised as decentralised and distributed in order to draw in the multiple specialist skills of the diverse City Corporation departments. The proposed governance structure could also form the basis of the implementation for the wider Climate Action Strategy.

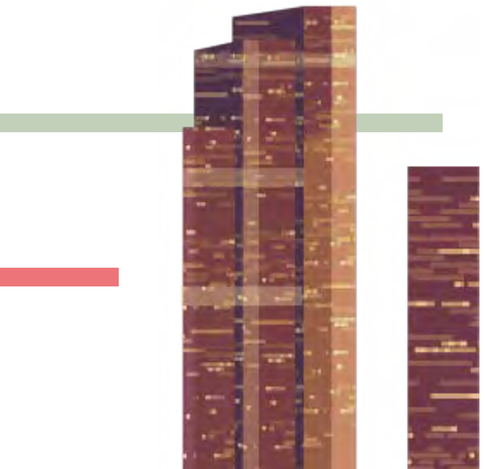
Based on work undertaken to inform the production of this strategy, it is proposed that the City Corporation consider focusing upon the following key actions during the next stages of the strategy's development:

- **Engage** The approach adopted to develop the content of this study has largely been 'top down'. There has been limited engagement with non-City Corporation stakeholders, notably businesses and residents, but also other public and private bodies. Engaging a wider range of stakeholders is recommended.
- **Collaborate** Some measures within the pathways will require close cross boundary and interagency working. As a key next step, it is recommended that the City Corporation test the plan with key interagency partners, with a view to refining this based on making the most of synergies and addressing any potential conflicts.
- **Diversity** The assets and users of the Square Mile and for those beyond this boundary that the City Corporation is responsible, are diverse. Processes of engagement and collaboration should take account of this diversity, helping to ensure the recommendations made are both representative and inclusive.
- **Uncertainty** and refinement How the climate will change is a complex, uncertain science driven by a great number of influences. The adopted approach advocates for a shift from a static risk management approach to a more dynamic (adaptive pathway) approach, which ensures the evidence base of this study will be reviewed and refined on a regular and ongoing basis. In turn, informing the future action planning and decision making of the City Corporation. The output of this study however is a framework for managing climate risks and a starting point for the continued evolution and implementation of an adaptation and resilience strategy.
- **Act now** The adaptive pathways presented within this strategy identify that early action is required and should be taken by the City Corporation now to build adaptive capacity in response to a number of the risks considered through the study. Short term actions in each of the funding strategy programmes are summarised below, more detail can be found in the pathways set out in the report:
  - **A climate readiness program** A number of short term preparatory actions focussed on pilot studies, research and initial resilience building activities like further emergency planning have been identified. Within these key opportunities have been identified, such as the likelihood that a number of key strategy documents (e.g. the Joint Health and Wellbeing Strategy) will be updated over the short term. The outcomes of proposed studies will inform future action planning and thus the completion of these is seen as a vital component of latter stages.
  - **Mainstreaming climate action** Ensuring an appropriate governance structure, key partnerships and development of the required skills, knowledge and capacity will be crucial to the successful implementation of the strategy. This will require multi-agency and cross departmental working, and require engagement with residents and other key stakeholders. This will be an ongoing process but action can begin today and help to build more successful longer term outcomes.
  - **Capital projects** Commencing a number of new capital projects proposed through this study will be vital to combat key risks. For example, based on the overheating thresholds identified it is recommended a wide scale building energy retrofit programme is progressed. This can likely be pursued in parallel with efforts to reduce carbon emissions. Other short term capital projects include a cool streets programme, new approaches to flooding and climate-resilient planting schemes Similarly, it will be necessary within this programme to identify planned capital projects and those underway, to identify how these align to the findings of the strategy and opportunities to unlock further positive outcomes for climate resilience.
  - **Strategic partnership projects** Building resilience and adaptive capacity will require action on behalf of all stakeholders and users of the Square Mile and the City Corporations assets across London. In parallel with the mainstreaming climate action program, investing in establishing relationships now, supporting and enabling others to act, will help to build more successful long term outcomes.

01 Introduction

The City of London Corporation

The City of London Corporation (City Corporation) is the governing body of the Square Mile, dedicated to a vibrant and thriving City within a globally successful UK. The City Corporation's reach extends far beyond the Square Mile's boundaries across the private, public and charitable and community sectors. The City Corporation owns, operates and supports a variety of assets in pursuit of a flourishing society, a thriving economy and outstanding digital and physical environments for the benefit of the residents, learners, workers, visitors and cross-sectoral stakeholders they work with.



City Corporation Climate Action Strategy

The City Corporation recognise the urgent need for positive action to reduce carbon emissions and increase resilience to changing weather patterns due to climate change. In the Responsible Business Strategy, 2018-23, the City Corporation committed to producing a Climate Action Strategy covering both mitigation of impacts from its own operations and those of the Square Mile as well as adaptation to climate change.

As a multi-sector organisation with a reach extending far beyond the Square Mile and convening power that enables the City Corporation to promote the interests of people and organisations across London, the UK and internationally, the City Corporation is in a strong position to make a positive contribution to London's and the UK's climate action efforts.

By taking decisive action now, the Square Mile and the City Corporation's assets across London and beyond will decarbonise and become climate resilient environments where people and businesses can thrive for generations to come. It is the City Corporation's intention to set credible net zero carbon targets for the Square Mile and across its own assets and to determine the climate resilience and climate adaptation measures that require investment, within the Climate Action Strategy for 2020 onwards. In doing so, the City Corporation can work to accelerate efforts to reduce carbon emissions, assist with a 'just transition' and ensure that the Square Mile remains a secure and progressive place to live, visit, study and do business.

Climate action will support the delivery of all aspects of the City Corporation's Corporate Plan for 2018-23, notably the aims 'To contribute to a flourishing society', 'To support a thriving economy' and 'To shape outstanding environments'. In order to inform the development of the Climate Action Strategy, the City Corporation has commissioned several studies. These are led by City Corporation officers and supported by four teams of consultants. The Climate Action Strategy is due to be agreed in 2020.

01 Introduction

Purpose of the Climate Resilience and Adaptation Study

Human activity since the industrial revolution has caused environments around the world to change significantly. The impacts of rising sea levels, increasing temperatures and more frequent and intense bouts of extreme weather are increasingly evident. All have implications for our way of life for people, business and other institutions.

Shaping climate resilient environments, where people and businesses can thrive for generations to come, is considered to be central to the Climate Action Strategy. The City Corporation have therefore commissioned this study to help inform the selection of climate resilience and climate adaptation measures that may be adopted within the Climate Action Strategy for 2020 onwards.

The purpose of the study has been to develop a risk-based approach to climate resilience, identifying thresholds and trigger points by which actions must be taken to ensure that the Corporation and the Square Mile remain resilient to the impacts of climate change. The approach has been based on the emerging adaptive pathway methodology. This is an approach to exploring and sequencing a set of possible actions over time. It focuses on the processes of decision making in the face of high uncertainty, enabling the strategy to respond to changing climate risk as well as patterns of vulnerability. The output is a starting point for the continued evolution and implementation of a City Corporation Adaptive Pathway framework for managing climate risks. Through the study, broad programmes have been proposed in response to the risks identified. These recommendations will require further scoping in later stages of the Climate Action Strategy. Many, indeed, will require their own adaptive pathway strategies.

The study considers six key risks as defined within the UK Committee on Climate Change (UK CCC) 2017 Climate Change Risk Assessment: flood risk, rising temperatures, water stress, natural capital, food production & trade and pests & diseases. It considers long-term resilience challenges facing the City of London area (the 'Square Mile') and the wider portfolio of City Corporation assets from now to 2050, and beyond.

The Adaptive Pathways Study is one of a number of studies commissioned by the City Corporation to inform the development of their Climate Action Strategy. There may be synergies between the recommendations of the other studies commissioned and potential to unlock wider opportunities. Similarly, there may be conflicts that need to identified, understood and resolved. It is anticipated that these will be explored by the City Corporation later in the Climate Action Strategy programme.

Content

The document is split into the following sections:

- **Why act now:** provides a brief insight to the human, environmental and economic imperatives for action, the City Corporation's work to date and the wider policy landscape in which the City Corporations adaptation and resilience building efforts sit.
- **Approach and methodology:** including an outline of the scope and boundaries of the project, an introduction to Adaptive Pathways planning, a review of the current position of the City Corporation, and an outline of key elements of this study.
- **Climate risk assessment:** a summary of the results of the initial climate risk assessment carried out for the Square Mile and City Corporation assets. This research forms the underlying research feeding into the pathways study, and establishes the key risks and objectives dealt with in this project.
- **Adaptive pathways planning:** an overview of the key objectives of the pathways and the pathways themselves. Recommendations are made in relation to the implementation of the strategy, notably proposed strategies for governance, funding and ongoing monitoring and evaluation are set out.
- **Conclusion and next steps:** a synthesis of the key findings and strategies developed through the Adaptive Pathways study.

Appendices are also provided which provide full technical detail and background on the methodology, a Climate Risk Assessment, copies of the risk specific pathways, details of the proposed pathway measures and preliminary monitoring and evaluation criteria.

02 Why act now?

The Paris Agreement, signed in 2015, has shown significant scientific and political consensus on climate change, pointing to the urgent need to limit carbon emissions globally in order to avoid catastrophic impacts to the society, economy and environment worldwide.[1] At this point, however, even the most ambitious carbon reduction scenario will result in climate impacts. This section provides a brief insight as to the need for action, the City Corporation's work to date and the wider policy landscape.

The Imperative for Accelerating Adaptation and Resilience

The Global Commission on Adaptation,[2] amongst many others, have set out the human, environmental and economic imperatives for accelerating climate adaptation and resilience action. Such calls to action are no less pertinent or urgent in the context of the City Corporation.

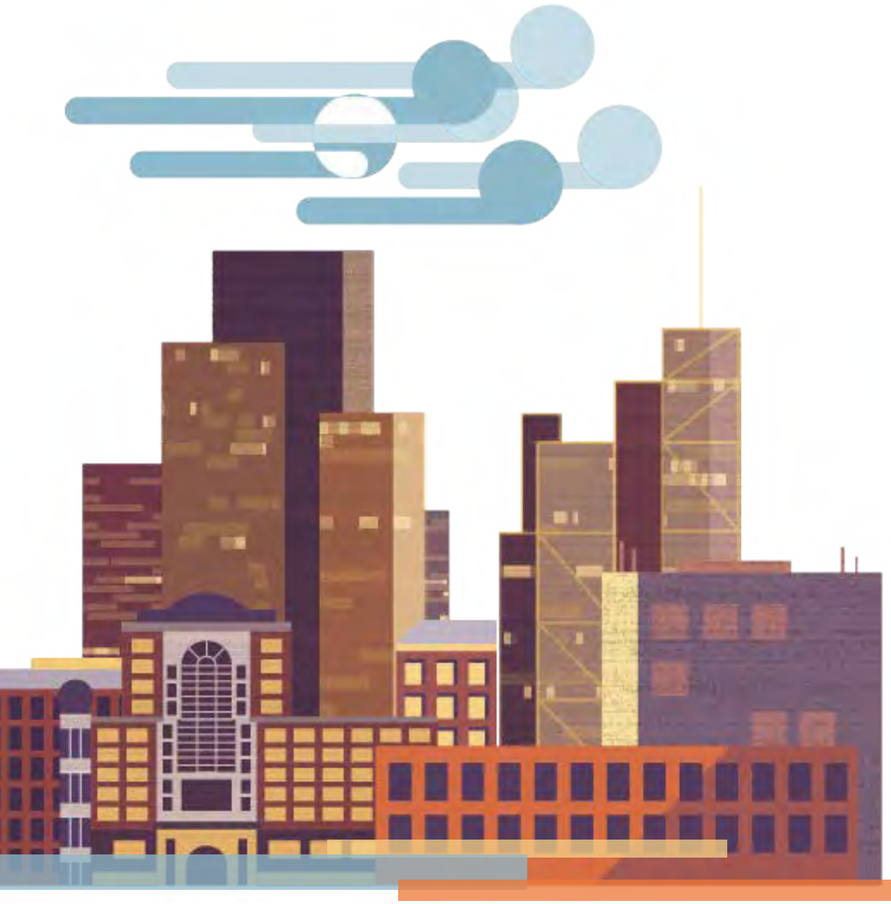
The Human Imperative

The impacts of climate change will be unequally distributed, with those most vulnerable disproportionately affected. The Square Mile's resident population is approximately 7,500 with 513,000 people commuting to the City to work each day. Moreover, the City Corporation has a role beyond the Square Mile, as a port health authority, a sponsor of schools, and the manager of many housing estates and green spaces across London. Of the Square Mile's resident population, the City Corporation Corporate Plan notes that those aged 65 and over represent a higher proportion of the total population than is average across London boroughs and the numbers will continue to grow. In contrast, there are relatively few children in the City. The City's children mainly live in dense pockets of housing with some areas experiencing high levels of deprivation. Levels of deprivation are typically higher in those areas outside the Square Mile where the City Corporation sponsors schools or manages housing estates. Whilst 70% of workers are deemed highly skilled, the City supports a number of service sectors jobs, demand for which may be typically met by individuals of higher vulnerability. An estimated 78% of the City of London population is white British; however, approximately 40% of children are from black or ethnic minority groups, compared to 21% nationally. The City of London has a diverse range of users. Though the impacts of climate change will be felt by all, those residential and working populations identified above – elderly, deprived, children, Black, Asian and Minority Ethnic (BAME) communities - some may be more vulnerable than others. Action to ensure continued health and wellbeing of all is crucial. It is imperative that action taken to adapt and build resilience to the impacts of a changing climate are equitable and that the benefits of these actions are fairly shared.

The Environmental Imperative

A thriving natural environment is fundamental: it is the basis of life and indeed humanity's first line of defence against many of the impacts of a changing climate. Despite this land conversion, overexploitation of ecosystems, and climate change are accelerating the loss of natural assets everywhere.[4] Climate change presents a substantial risk to the vital goods and services provided to people by the natural environment: clean water, food, pollination, carbon storage, flood alleviation and cultural services.[12] These risks are heightened because of the stresses (habitat loss, pollution, abstraction) we are placing on the natural environment. The Square Mile contains roughly 375 green spaces which have important wellbeing and local biodiversity roles. In addition, the City Corporation owns or manages almost 4,500 hectares of historic and natural open spaces outside of the Square Mile boundary. There is still time to protect and work with nature to build resilience and reduce climate risks at all scales, but the window is closing. We have a clear picture of the value of nature, as a key landowner the City Corporation can play a significant role in promoting action to build natural capital.

02 Why act now?



The Economic Imperative

The Stern Review[5] established that the costs of stabilising the climate are significant but manageable; delay would be dangerous and much more costly. The Review estimates that if we don't act, the overall costs and risks of climate change will be equivalent to losing at least 5% of global GDP each year, now and forever. In contrast, the costs of action – reducing greenhouse gas emissions to avoid the worst impacts of climate change – can be limited to around 1% of global GDP each year. The impacts of inaction will be directly felt in the Square Mile, for example without action it is estimated by the London School of Economics that London could experience losses of 0.4% to its Gross Value Added due to heat stress and productivity losses by 2100.[6] 24% of these losses would be experienced within the Financial Sector, a key industry in the Square Mile. As cited by the Global Commission on Adaptation,[2] while avoiding losses is the most common motivation for investing in resilience, taken alone such losses underestimate the total benefits to society. Many adaptation actions generate significant additional economic, social, and environmental benefits, which accrue on an ongoing basis starting at the time of investment and are not dependent on the future state of the climate. In other words, they are both more certain and more immediate.

Accelerating adaptation and resilience is critical to maintaining the productivity and contribution of the Square Mile to the UK and global economy. Action is fundamental to positioning it as a resilient and attractive place to live and do business. The City is a world leader in green finance and insurance, and so reducing climate impacts and responding to climate threats is key to its role as a leading global financial centre. To remain credible in promoting these business priorities the City, with support from the City Corporation, must be at the forefront of climate action through its own activities and innovation in the climate action space.

Current position and actions

The City Corporation published its existing Climate Change Adaptation Strategy in 2010. Within this, forecast changes in climate are based on the 2009 UK Climate Projections and the strategy primarily focuses on managing flood risks, water resources, heat stress and air pollution, ground conditions and cross cutting issues. It identifies adaptation options which have been grouped into research and monitoring, or policy and practical actions.

Climate resilience also sits within a collection of intersecting plans and strategies produced by the City Corporation, albeit to varying degrees. For example, the Transport Strategy, Biodiversity Action Plan, Strategic Flood Risk Assessment, and (draft) City Plan 2036. These documents provide important context and scope. The findings of this study aim to complement and build off of this work, and to then inform future iterations of City Corporation plans and strategies.

Key areas of work to date have included expansion of Sustainable Urban Drainage networks in the Square Mile, research and management of its extensive natural spaces across Greater London and through the Transport Strategy significant effort to build resilience of roads and open spaces. The Corporation has worked extensively with partners like the Environment Agency,[7] the Greater London Authority (GLA) and Thames Water to align with initiatives and requirements to report and mitigate impacts of risks around flooding, environmental management and drought.

02 Why act now?

Policy landscape and alignment

Preparing for, and developing resilience to, the shocks and stresses that will emerge with changes in the future climate will require collaborative action. As illustrated in Figure 2-1, there are many existing national and regional policies as well as strategies developed on behalf of the public and private sector that are already contributing to building resilience.

This plan sits parallel to London-wide and national efforts to improve resilience of our communities and urban spaces. Crucially this includes the GLA London City Resilience Strategy 2020,[8] UK CCC Climate Risk Assessment 2017[12] and National Adaptation Programs[13] as well as the landscape of policies set out by government.

Many of the measures presented in the pathways will require close alignment with other strategies and plans produced by others. As such, in developing the forthcoming Climate Action Strategy, it is recommended that the City Corporation seek to build alliances and partnerships with others. This priority is embedded into both the monitoring recommendations (Appendix E) and measure guidance itself (Appendix D).

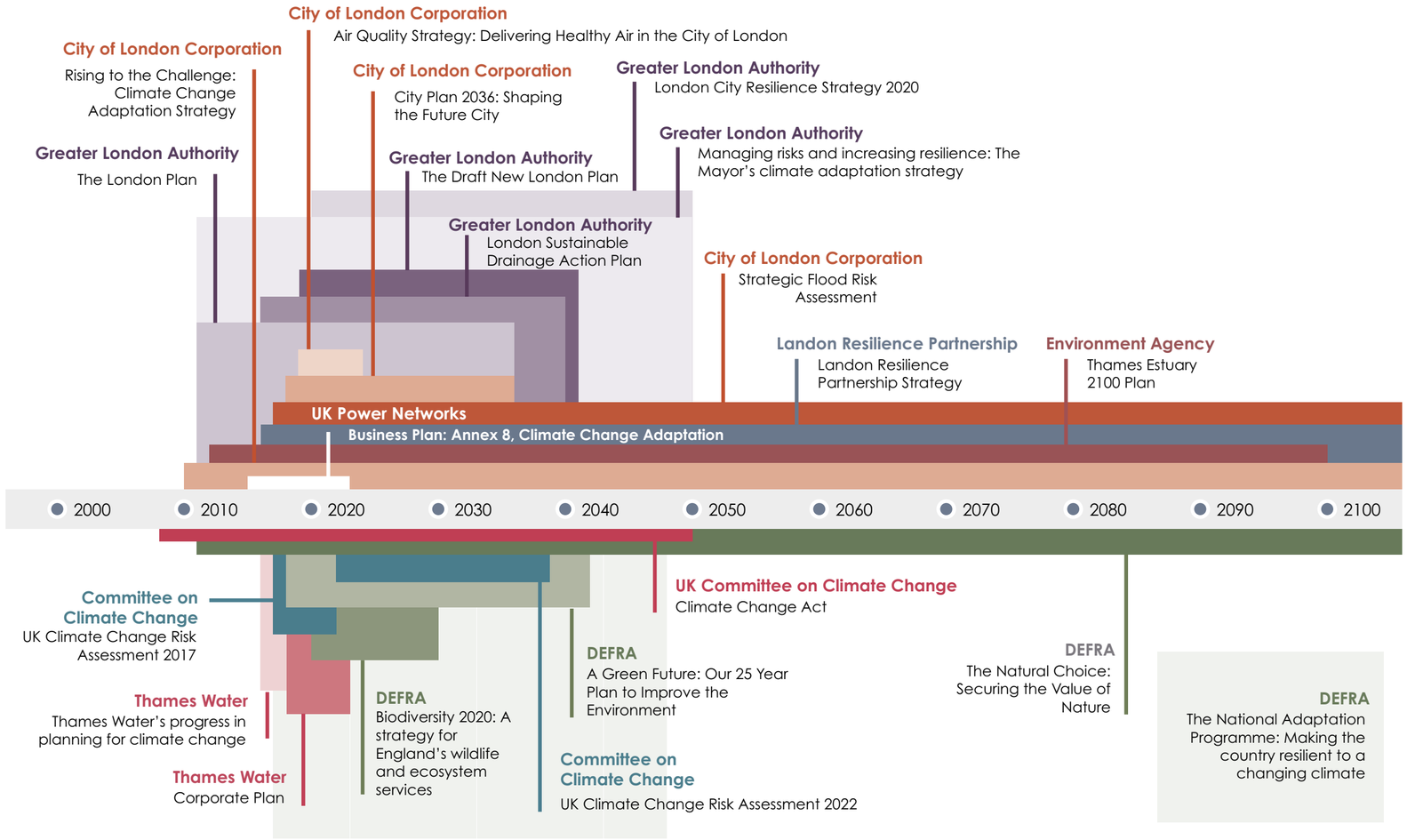
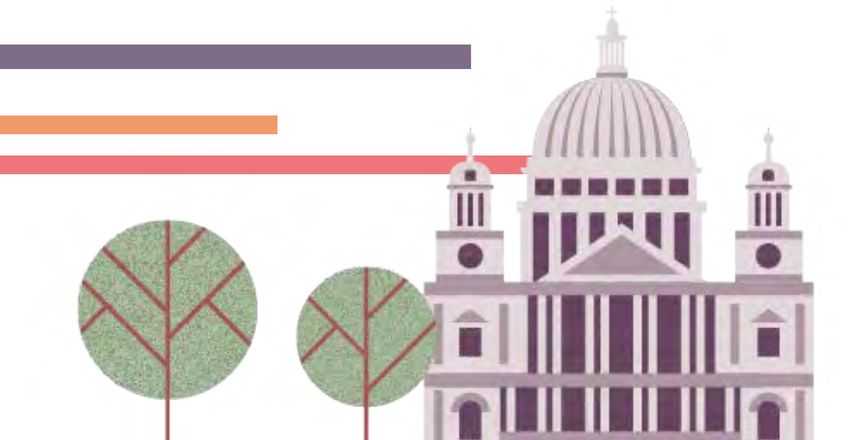


Figure 2-1 Policy landscape around the City of London Adaptive Pathways study

03 Approach and methodology

The Adaptive Pathways study intends to identify and programme measures that the City Corporation may adopt to build resilience of the Square Mile and the City Corporation's assets to the risks associated with climate change. This section sets out the approach and background to undertaking this exercise, covering the initial research and analysis methodology, the process of designing the pathways and the approach used to make final recommendations.



Key terminology

Resilience

The ability of a system and its component parts to anticipate, absorb, accommodate, or recover from the effects of a hazardous event in a timely and efficient manner, including through ensuring the preservation, restoration, or improvement of its essential basic structures and functions.[9]

Adaptation

In human systems, the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities. In natural systems, the process of adjustment to actual climate and its effects; human intervention may facilitate adjustment to expected climate. [9]

Shock

Sudden impact events that can immediately disrupt a city and may have wide-ranging and unexpected impacts.[8]

Stress

Chronic issues that weaken the fabric of a city and can eventually lead to a major shock.[8]

Risk

Risks are typically defined as exposure to danger, harm or loss. In the context of this study, risks will be based upon the 2017 UK Climate Risk Assessment and the City Corporation Climate Risk Assessment (refer to Appendix B). To summarise, these include: flooding, overheating, water stress, threats to natural capital, food production and distribution and new / emerging pests and disease.

Adaptive capacity

The combination of the strengths, attributes, and resources available to an individual, community, society, or organization that can be used to prepare for and undertake actions to reduce adverse impacts, moderate harm, or exploit beneficial opportunities.[9]

Adaptive pathway

The set of sequential actions over time implemented to mitigate the potential impacts of climate change. Pathways presented will include a range of 'no-regret' actions to be adopted early and identify clear future thresholds to determine when decisions are required to manage future risks. In turn, avoiding the need to take 'inflexible' decisions now.

Threshold

Thresholds may be biophysical or social, or management related but based on the objectives set they are the points in time linked to when change is anticipated and that determines the type of response based on the appraisal of impacts and acceptability. Threshold types very – some relate to physical factors which will have widespread impacts, others relate to national policy targets. This approach accounts for the broad nature and varying evidence base underpinning the risks explored within this study.

Time horizon

The periods (no. of years) over which the adaptive pathways will be mapped. Within this study the time horizon is based upon the five-year sequential periods adopted by the UK National Adaptation Plan: 2019-2023, 2024-2028, 2029-2033, 2034-2038, 2039-2043, 2044-2048 and 2049 onward.

Emission scenario

Predicting climate change requires us to forecast future trends in human activities (e.g. population growth, land use change, technology advancement). Relative Concentration Pathways (RCPs) make predictions of how concentrations of greenhouse gases in the atmosphere may change as a result of human activities. There are four commonly used RCP's, ranging from RCP 2.6 (low emission pathway) and RCP 8.5 (high emission pathway). For the purpose of this study, two emission scenarios are considered: a low and high emissions scenario, based on RCP 2.6 and RCP 8.5 respectively. There are a range of possible futures within each pathway, so percentiles are used to indicate the likelihood of a particular result happening.

03 Approach and methodology

What is an adaptive pathway?

The adaptive pathways approach focuses on establishing combinations of sequential measures – pathways – to mitigate the potential impacts of climate change in future decades. Measures may not only be single measures, but portfolios of actions that will be implemented simultaneously. The concept of a pathway focuses on the processes of decision making, rather than the outcome; emphasising the adaptive nature of the decision process itself in the face of high uncertainty.

The approach is an iterative and ongoing one, in which choices along pathways can be altered in response to predefined triggers. Triggers may be a physical parameter (such as temperature) and therefore change with time, or simply involve making a decision for action at a later date, when more information will be available. In turn, the adaptive pathways and the Climate Resilience Strategy these underpin should be regarded as a 'living', evolving plan.

The extent to which the climate may change by the end of the century is a complex science with much uncertainty, making climate resilience planning particularly suited to an adaptive pathways approach. Accordingly, it has grown in popularity for use in climate planning initiatives in recent years – for example forming the approach for the Environment Agency Thames Estuary 2100 (TE2100) flood defence plan for London, and for the management of shipping along the Rhine Delta in the Netherlands. [10]

The adaptive pathways approach is being used by the City Corporation to build the resilience of the Square Mile and other assets, with a unique pathway having been designed to tackle each of the six risks highlighted in Section 3. The adaptive pathways approach has been tailored to the needs of the City Corporation. Whereas previous applications have focused on defining detailed responses to a particular challenge, for example the level of urban greening and building upgrade required to mitigate heat related ill-health and mortality during heat waves under different climate scenarios (as explored by Kingsborough, et. al., 2017), [11] the intention of this study has been to identify when unacceptable risk may occur and broad programmes of action that may be appropriate to mitigate these. This allows the City Corporation to lay out a structured, flexible plan to build resilience, with monitoring and adaptation to the situation built into the programme. The broad programmes of action will require further scoping and indeed may require their own adaptive pathways to be built. The requirement for such action has been built into the planning of the pathways.

Scope and boundaries of the study

The UK Climate Risk Assessment 2017[12] identifies the 'top six areas of inter-related climate change risks for the UK'. It is these risks that the Adaptive Pathways study looks to mitigate and alleviate:

1. Flooding and coastal change risks to communities, businesses and infrastructure, with specific reference to their impacts in the Square Mile and on City Corporation Assets elsewhere;
2. Risks to health, well-being and productivity from high temperatures;
3. Risk of shortages in the public water supply, and for agriculture, energy generation and industry;
4. Risks to natural capital, including terrestrial, coastal, marine and freshwater ecosystems, soils and biodiversity;
5. Risks to domestic and international food production and trade; and
6. New and emerging pests and diseases, and invasive non-native species, affecting people, plants and animals.

These risks were explored in the context of the Square Mile and City Corporation assets, with adaptive pathways designed to tackle them through a mixed-methods multi-stage process described within the subsequent Section. This document outlines the key findings through this process and presents a proposed Adaptive Pathway for each risk.

The Adaptive Pathways contain suggested programmes of of action which look to mitigate or alleviate different elements of the risks under consideration, with detail, key considerations and discussion as to their implementation. Some measures are defined in relation to particular climate or infrastructural thresholds or triggers, and as such would not be implemented immediately, but should be monitored, and steps to undertake them in future followed. This means that the Adaptive Pathways are intended to be a living, evolving plan, updated as conditions over future decades become clearer, and providing flexibility for actions to respond to the many changing factors at play.

Preliminary costings are provided to help integrate these measures into action planning and strategies, and the pathways are designed in alignment with the time periods of the UK National Adaptation Plans[13] and Climate Change Risk Assessments.[12]

This document is not intended to be an evidence base for specific measures but identifies when action may be required and broad programmes of measures that may be appropriate for the City Corporation to pursue in order to build resilience to the six risks that underpin this study.

Technical documents and additional information are available in the Appendices.

03 Approach and methodology

Methodology

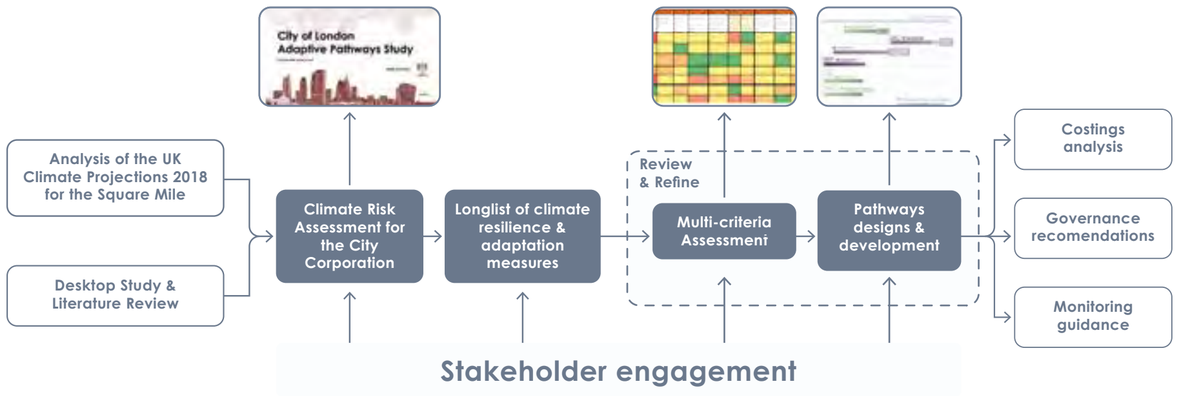
This study follows a mixed-methods approach to designing the Adaptive Pathways as summarised in Figure 3-1. Further detail of the methodology adopted is provided in Appendix A.

Following quantitative analysis of the Met Office UK Climate Projections 2018 (UKCP18) to determine potential climatic conditions in future decades, a desktop study into the potential impacts of the six risks identified in the UK Climate Change Risk Assessment 2017 was carried out. These findings were used to compile a baseline, unconstrained vision of impacts to the future City Corporation area of responsibility without action. Against this, a longlist of possible adaptation measures was prepared. These two components were presented to stakeholders to gain insight into their preferences for intervention and types of measures to prioritise. This information was then synthesised using a multi-criteria analysis to highlight measures which would be appropriate to prioritise and remove from City Corporation programmes. The streamlined measures were then designed into pathways using an iterative programme of costings, assessment scores, scheduling and climatic threshold requirements.

This method is highly structured, presenting a data-driven analysis of risks to the City Corporation operations. This ensures all conclusions are evidence based, allows appropriate scaling the level of vulnerability to which the Adaptive Pathways must respond and provides detailed, reliable insight into predicted future impacts. This approach also presents quantitative figures against which thresholds and objectives can be set and monitored.

Key actions under each of these steps included the following:

- Climate assessment: this involved an analysis of the Met Office UKCP18 for average temperatures and rainfall (probabilistic models for high and low emissions scenarios – RCP 2.6 and 8.5) and an assessment of high emissions scenario regional datasets for extreme weather variables.
- Risk assessment for the Square Mile synthesising the findings of the climate assessment with those from the desktop study around the core risks, vulnerabilities and considerations for the Square Mile and City Corporation assets.
- A longlist of measures was drawn up based on the existing activities of the City Corporation as well as a literature review of climate risk assessments and resilience strategies, international guidance and other studies.
- Stakeholder engagement was carried out through a half day workshop with major stakeholders and subject Figure matter experts connected to the Square Mile and City Corporation – including the Environment Agency, City Corporation officers, the Met Office and service providers.
- The multi-criteria assessment drew together the literature review and stakeholder feedback to build a detailed analysis of the longlist of measures again a diverse set of criteria: costs, effectiveness, co-benefits and more (see Appendix A).
- The design of the pathways was an iterative process, undertaken with City Corporation officers involving the following actions:
  - The multi-criteria assessment was used to explore the highest and lowest ranking measures, with low scoring, unfeasible and ineffective measures excluded;
  - A qualitative review was used to schedule remaining measures by their programme type: ongoing, one-off preparatory or adaptive (triggered by a certain climatic or measurable threshold);
  - Thresholds were identified using the results of the Climate Risk Assessment and measures scheduled on the pathways plots (See How to read the adaptive pathways); and
  - Resulting pathways were reviewed against multi-criteria results and a qualitative assessment of groupings and scheduling, with further changes and exclusions made iteratively in collaboration with the City Corporation until a final set of pathways was reached.



3-1 Pathways development process

04 Climate Risk Assessment

The Square Mile is located in the centre of London, with a border against the River Thames. It has a modest local population and large visiting population,[14] for which temperatures, weather patterns and resource stresses will have a direct impact. As explored in the following sections, assessment of the UKCP18 indicate that weather patterns projected for inner London align with those projected for the wider UK and South East region: hotter, drier summers, with warmer, wetter winters. This correlates with more frequent, intense and longer heatwaves, a reduction in snowfall and the potential for extensive periods of drought in future decades under both high and lower emissions scenarios. This section provides a summary of the Climate Risk Assessment produced by the project team; a copy of the complete Climate Risk Assessment has been provided in Appendix B.

Note: the impact of the Urban Heat Island Effect is not included in the UKCP18 analysis. Without an expansion of green spaces and other cooling strategies, the urban heat island in London may contribution additional degrees to temperatures under all emissions scenarios.[15] Flooding and sea level rise are also not mapped here since they are modelled in the TE2100 plan, not the UKCP18.

How will the climate change?

Average temperatures and rainfall

For both high emissions and low emissions scenarios, the Square Mile and the City Corporation's assets beyond this are set to see increasing average air temperatures and a variation in rainfall patterns (Figure 4-1).

By 2080, under the high emissions scenario, summer average temperatures may increase by nearly 5°C, and winter by about 3°C. Under a lower emissions scenario, in 2080, average increases in temperature will be limited to around 1-2°C, more similar to the temperatures we see today. Today, we are seeing summers that are, on average, around 0.5°C warmer than the 1981-2000 average, with comparable winter temperatures.

Future rainfall patterns are split seasonally, with drier summers and wetter winters forecast. Both scenarios suggest that summer rainfall is set to decrease by around a third by 2080, and winter rainfall to increase by around 20% by 2080. This links to the findings in Section Four, which indicate that extreme weather patterns (e.g. drought and heatwaves) are set to increase.

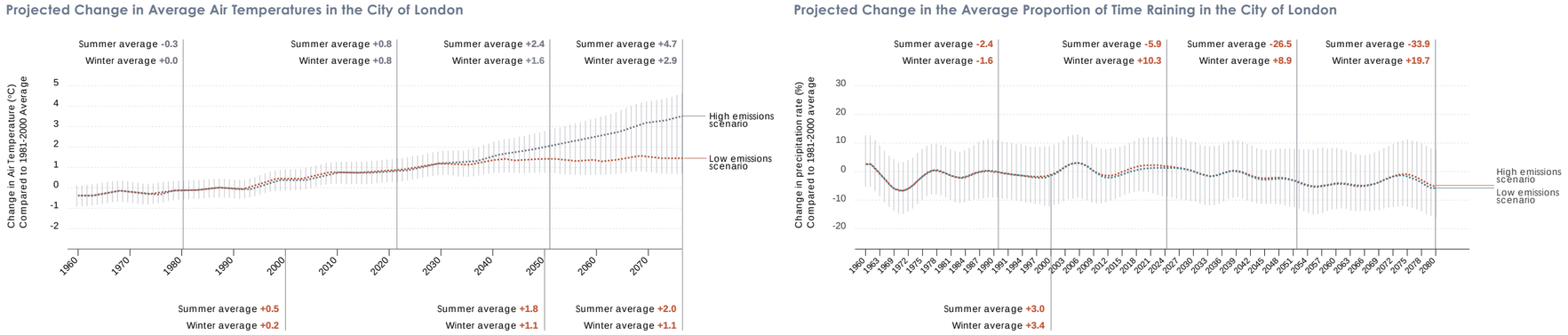


Figure 4-1 Change in average air temperatures and average precipitation rates under probabilistic UKCP18 projections for low and high emissions scenarios (RCP 2.6 and 8.5 respectively). Uncertainty in modelling means we could see even higher temperatures and more variable rainfall patterns. The grey hatching represents a range of possible results for the two scenarios (25th and 75th percentile).

04 Climate Risk Assessment

Worst case weather patterns

Several severe weather scenarios were investigated, as summarised in Table 4-1. These indicate that extreme temperatures and dry summers risk intense heatwaves and droughts in the Square Mile, though the impact on thermal comfort may be somewhat offset by a reduction in relative humidity. Snowfall rates will fall significantly with rising temperatures, and wind speeds are not set to vary more than natural variation already experienced today.

Potential risks associated with changes in future climate

The second part of the risk assessment looked to analyse the relevance of the six key risks identified in Section 3 to the Square Mile and City Corporation assets, drawing on the climatic analysis, City Corporation data and expertise and publicly available literature. Table 4-2 indicates some of the key considerations identified, all of which have informed the development of the adaptive pathways presented later.

Weather type or event	Trend
Thermal Comfort	Currently, in the summer months, high temperatures combined with high relative humidity and low wind speeds creates humid, uncomfortable thermal conditions. Under UKCP18 projections, while temperatures in the Square Mile are anticipated to increase substantially, relative humidity is set to decrease. This decrease in relative humidity will help to offset some discomfort related to rising temperatures.
Snowfall	Increasing temperatures will correlate with a rapid decrease in the amount of winter snowfall – up to two thirds decrease by 2080 in a high emissions scenario. The amount of snow settling is likely to be a fraction of this amount, given rising land temperatures and the Urban Heat Island Effect.
Maximum temperatures and heatwaves	The predicted maximum daily air temperature is set to rise steadily in the forthcoming decades. By 2080 maximum air temperatures may be around 5°C higher than those we see today. In line with rising air temperatures, the frequency and duration of heatwaves are set to increase in coming decades. By 2080, we may see four times the number of days of heatwave compared with today, some lasting up to three weeks.
Rainfall and droughts	The five wettest days of the year are set to get wetter in future periods, with up to 20mm more rainfall in the five wettest consecutive days of rain in future years compared to those predicted for 2020. Like heatwaves, droughts are predicted to get longer and more frequent under a high emissions trajectory, with nearly double the days of drought predicted in 2050 compared to 2020. However, there is some fluctuation, as seen by the comparable number of days of drought in 2080 to today.
Wind Speeds	In the London Region, the 12km UKCP18 projections indicate that wind speeds are anticipated to remain constant in future decades. A slight increase in winter, and decrease in summer, wind speeds can be seen in the projections, at a magnitude of less than 0.5m/s. The Met Office notes that changes to the North Atlantic Oscillation weather system may also occur, which may influence weather patterns.6 However, these changes are all 'expected to be much smaller than the natural variability [wind] exhibits from month to month and season to season', meaning as yet there is no proof that wind storms will increase in frequency or intensity under climate change.

Table 4-1 Summary of worst-case weather change patterns in the Square Mile

04 Climate Risk Assessment

Risk	Description	Key risks and considerations in the Square Mile	Current work and infrastructure	Risks to assets outside the Square Mile
1 – Flooding and coastal change risks to communities, businesses and infrastructure	Surface water flooding, flooding from the Thames and groundwater floods are all risks in the Square Mile, and could affect hundreds of properties, organisations and critical infrastructure if unmanaged.[7] Climate change is set to alter rainfall patterns and increase sea level rise in the UK. In wet periods this means an increase in flood risks in the Square Mile, affecting more properties and infrastructure, again primarily from rainfall-induced surface water flooding. As sea levels rise, the risks of flood defence failure and subsequent damage will also increase, compounded by aging asset infrastructure.	For 40% rainfall increases under climate change,[16] surface water floods could extend to cover an additional substation, and numerous commercial and residential properties.[7] Future river flood risk similarly will affect additional properties and infrastructure over today's levels. A number of critical utility lines run at a deep level below Farringdon Street.[6] Whilst likely designed with future climate in mind, potential impacts of extreme events on the functioning of these assets should be considered. The risk of groundwater flooding in the context of climate change is less well understood than other types of flood risk. Preliminary research suggests that groundwater levels will fall, reducing flood risk.[17]	Flood defences for river flooding are currently maintained by riparian owners under a comprehensive programme of works by the Environment Agency and TE2100 plan. [18] Surface water flooding is controlled by urban drainage systems, and groundwater flooding through the GARDIT system. Activitiesexist to incentivise and encourage greater numbers of Sustainable Urban Drainage – including through planning requirements for minimum urban Greening Factors on developments.	Assets outside of the Square Mile will also be subject to flood risk as per assessments in their local areas, controlled by the relevant local authorities.
2 – Risks to health, well-being and productivity from high temperatures	Rising temperatures and heatwave intensity are both anticipated in the Square Mile. These could have severe health implications: studies indicate that future heat-related mortality could rise by as much as 540% in the 2080s, compared with the 2000s baseline of around 2,000. [19] Rising heat will also have effects on health services, which already see spikes in demand during hot weather, infrastructure functionality, access to outdoor spaces for exercise and wellbeing, disease and pathogen transmission and air pollution levels.	Square Mile residents are disproportionality elderly, and workers are predominantly professional workers, [20] 33% of whom suffer long-term physical ill-health conditions. [21] Both of these factors increase risks of heat-related ill-health. 56% of domestic EPC ratings awarded between 2017-2018 in the City of London were rated C or less efficient. The borough has over 600 listed buildings and an aging building stock, in turn it is expected that a significant proportion of the existing building stock will be challenged to cope with overheating conditions.	The City Corporation has considered overheating risks through its Transport Strategy, planning requirements and work on its Joint Health and Wellbeing Strategy.[34] Retrofit programmes are increasingly popular, with the Greater London Authority and other public bodies increasingly moving towards providing funding and support for retrofitting homes to build resilience. Strategies to minimise overheating risk are often, but not always, built into refurbishment cycles by commercial asset owners.	Assets owned outside the Square Mile will also be vulnerable to rising temperatures. There is a particular risk for those assets which are older or poorly maintained, or where residents are positioned further from health services and emergency responders. City Corporation parks also cover over 4,500 hectares and are used by millions for health, exercise and recreation.[19] Not being able to use these spaces in periods of heat could have large wellbeing repercussions.

Table 4-2 Overview of risk assessment for the Square Mile and City Corporation assets

04 Climate Risk Assessment

Risk	Description	Key risks and considerations in the Square Mile	Current work and infrastructure	Risks to assets outside the Square Mile
3 – Risk of shortages in the public water supply, and for agriculture, energy generation and industry	Without action, demand for water could be more than 150% of the available resource in many catchments across the UK in future decades, [3] with WaterUK, [24] indicating that the biggest forecast percentage water deficits in the UK will be seen across London and the South East. Droughts may bring acute periods of water stress, with knock-on disruption to energy generation and industry, and further risks surrounding public health, infrastructure and food supplies.	Regional water shortages could bring intersecting disruption through knock-on effects on irrigation for agriculture, energy production and ecosystem disturbance. Non-domestic buildings typically have one day's water storage, meaning water stress could have implications for productivity. With no reservoirs and little additional space of its own, the Square Mile is dependent on water from Thames Water, with few options for diversification.	The City Corporation works closely with Thames Water in the instance of leaks of water shortages and public communications campaigns are used during hosepipe ban periods, with measures taken to try to reduce demand and water consumption.	Assets outside the Square Mile are subject to similar constraints and risks to water supply as the Square Mile. Square Mile resident Park spaces and water bodies in Greater London run by the City Corporation rely on irrigation regimes and could be seriously affected by droughts, where water is necessary to support conditions.
4 – Risks to natural capital, including terrestrial, coastal, marine and freshwater ecosystems, soils and biodiversity	Climatic changes fundamentally alter natural trends and ecosystems, which can impact the natural systems which we depend on for goods and services, as well as causing decline and loss within ecosystems themselves. With only 13.1% of the Square Mile made up of green or blue infrastructure, the consequences of this risk to the Square Mile may be localised, but not insubstantial.	Key urban species have habitats in the Square Mile, including bats, bumblebees and Peregrine Falcons.[25] Connectivity of green space across London and continuous ecological corridors are important for species across London, not just in the Square Mile. Outbreaks of pests and diseases among plant populations are critical risks in England (see risk 6).	Urban greening initiatives and green space management are core City Corporation functions. Through the actionsv within the Biodiversity Action Plan [25] the City Corporation has undertaken numerous studies and research exercises into management of its open spaces, though this strategy suggests improvements to the plan are required	The City Corporation manages over 4,500 hectares of green space outside the Square Mile, including large Sites of Special Scientific Interest, ponds and reservoirs. [26] Management of these spaces under a changing climate will be essential to enable people to continue to use them and to continue to harness their diverse flooding, air pollution, sequestration and economic co-benefits. Droughts also risk wildfires such as those experienced at Epping Forest in 2018.

Table 4-2 Overview of risk assessment for the Square Mile and City Corporation assets

04 Climate Risk Assessment

Risk	Description	Key risks and considerations in the Square Mile	Current work and infrastructure	Risks to assets outside the Square Mile
5 – Risks to domestic and international food production and trade	A consequence of many of the previous risks in this study has been disruptions to food supplies. Food in the UK is 40% imported, [27] with UK food and drink exports annually exceeding £20bn. [28] This combination makes food infrastructure affecting the Square Mile vulnerable to national and international shocks and stresses, which may include weather-related shifts in agricultural production, geopolitical crises and events, legislation gaps and volatile food prices. [19]	The London Resilience Strategy 2020 [8] similarly places food infrastructure vulnerability as a key risk for the London area, and notes that food insecurity is already an issue: 21% of Londoners already live in low or very low food security. [29] Food shortages and price volatility are key threats to residents, visitors and businesses in the Square Mile. The Square Mile has negligible urban agriculture, making it heavily dependent on out-of-borough infrastructure.	The City Corporation has a thriving infrastructure of small food and drink businesses in the Square Mile – including 800 pubs and restaurants – with approximately £7.5m spent by the working population on food on a weekly basis (Buro Happold analysis, refer to Appendix B).	The City Corporation serves at the port health authority at numerous ports across Greater London, and runs several regional and international food markets. Managing resilience at these locations effectively has huge implications across the UK and beyond. Additional challenges are posed here, with international pest and disease transmission being a key risk.
6 – New and emerging pests and diseases, and invasive non-native species, affecting people, plants and animals	Milder, wetter winters and warmer summers would significantly raise the threat of pests and diseases in the UK. [19] These conditions will facilitate the spread and emergence of vectors like ticks, mosquitos and rats, and increase both transmission rates and overwinter survival rates. Pathogens may also survive better with warmer incubation temperatures allowing them to proliferate more quickly. Particularly acute impacts are possible in London given its high density and the international traffic passing through it.	Studies note that urban trees are at particular risk of new pathogens and pest outbreaks, since the global trade in 'plants for planting' is a pathway for their accidental introduction.[30] Equally, the UK Plant Health Risk Register contains approximately 1,000 existing pests and diseases. Changing climatic conditions may increase survival rates of existing pests and diseases, in turn increasing risks, particularly to vulnerable species. Strain on medical infrastructure, which is already limited in the Square Mile may increase substantially under rising spread of pests and diseases. Advice indicates that disease outbreaks will disproportionately affect dense urban areas. The City Corporation can have a role in managing urban flow and transition through its transport strategies and management of open spaces, as seen during the COVID-19 crisis.	The City Corporation has connections with healthcare providers throughout the Square Mile and its surroundings, with a dedicated Joint Health and Wellbeing Strategy.[33] It provides mapping of healthcare centres online, and manages pest and disease outbreaks in its natural capital.	Pest and diseases outbreaks in the City Corporations out of borough parks would have severe impacts, particularly in important Sites of Special Scientific Interest. It may also be the case that the City Corporation's residents out of the Square Mile are more vulnerable to diseases than those within the Square Mile, who are disproportionately wealthy against the London average. [32]

Table 4-2 Overview of risk assessment for the Square Mile and City Corporation assets

05 Adaptive Pathway Planning

This section introduces the proposed City Corporation Climate Resilience Adaptive Pathways. It considers the vision and objectives of the project, as introduced in Sections 1 and 2. It then presents the combined Adaptive Pathway – a sequence of actions proposed across all risks – and risk specific pathways – the selection of measures intended to combat each risk (from those highlighted in Section 4) individually. A summary of the measures and actions included in the pathway is presented, followed by monitoring, implementation, governance and finance considerations.

Purpose, Vision and Objectives

Purpose

The purpose of the Adaptive Pathways Study is to develop a risk-based approach to climate adaptation and resilience, identifying thresholds and trigger points by which actions must be taken to ensure that the Corporation and the Square Mile remains resilient to the impacts of climate change. This will be a dynamic, living approach that facilitates short-term actions to prepare for growing risks and challenges in future years, and establishes a guiding framework to ensure the City Corporation remains responsive to potentially more extreme future scenarios and that such climate projections are integrated into the planning, monitoring and management horizon for the City.

Vision

The City Corporation envisages a vibrant and thriving City, supporting a diverse and sustainable London within a globally-successful UK. The Adaptive Pathways will support the core aims set out within the City Corporation's Corporate Plan:

Contribute to a flourishing society

The adaptive pathways will work to ensure that **people are safe and feel safe** and are able to **enjoy good health and wellbeing** in the face of climate change. The pathways will enable the City Corporation to be proactive, facilitating short term action whilst identifying longer term needs that can be planned for. Inclusive climate action will be central to the pathways. Those most vulnerable will be supported, and measures proposed will be designed to ensure that all **people have equal opportunities to enrich their lives and reach their full potential**. Individuals and communities will be vital to the success of the pathways, pathways are designed to continue to build **communities that are cohesive**.

Support a thriving economy

The risk of not acting is significant. Through proactive risk identification and management, the City Corporation will be well placed to deliver inclusive and sustainable growth. Doing so will help build the City's reputation as **a global hub for innovation in financial and professional services, commerce and culture** – as well as unlock new opportunities for these sectors. Such action will **attract skills and talent**, and help to **build a network of businesses that are trusted and socially and environmentally responsible**.

Shape outstanding environments

The pathways will be critical to ensuring City Corporation **spaces remain secure, resilient and well-maintained**. Through acting proactively the pathways will **inspire enterprise, excellence, creativity and collaboration** furthering the world class reputation of the City and ensuring this is retained for years to come. A **thriving and sustainable natural environment** will be critical to the longer-term resilience of the City Corporation, the pathways will protect and enhance these assets. The pathways will rely on a network of **connected, responsive digital and physical assets**.

Objectives

The pathway objectives listed in Table 5-1. These set out the key challenges for the City Corporation under each risk, and each risk is matched with three or four objectives. The objectives provide the basis for understanding success of the actions taken within the Adaptive Pathways (refer to Appendix E where proposed monitoring criteria have been identified).

Objectives tend to focus on different combinations of impacts and groups or areas which will be affected, as identified in the climate risk assessment (Appendix B). For some risks, like flooding, the area of influence is broad and well-defined in the climate risk assessments, with known impacts – critical infrastructure, businesses, and properties are all affected by multiple sources (surface water, ground water and river flooding). For others, like overheating, there are many cross-cutting and broad impacts in the literature, of which only certain areas have been identified as being key considerations for the City Corporation (Section 4) – for example vulnerability of infrastructure, wellbeing risks and mortality are specific considerations to be tackled.

05 Adaptive Pathway Planning

Risk	impact	Number	Objective	Justification for selection
1 – Flooding and coastal change risks to communities, businesses and infrastructure	Surface Water flooding. Ground water flooding.	1	Minimise vulnerability of critical infrastructure, businesses, residents and visitors to flood events.	The Square Mile Strategic Flood Risk Assessment [7] indicates that all of these risks and impacts exist today and will be adversely affected by a changing climate.
	River wall breaching.			
	River wall overtopping.			
2 – Risks to health, well-being and productivity from high temperatures	Infrastructure, residential and commercial vulnerability.	2	Minimise vulnerability of critical infrastructure, businesses, residents and visitors to rising temperatures and extreme heat events.	Overheating in buildings and major infrastructural disruption is a likelihood at high future temperatures, so preparedness to these events is key.
	Decreased productivity and wellbeing.	3	Increase preparedness and ability to cope with increased thermal stress.	Rising temperatures, particularly where buildings are not cooled, will adversely affect the health and productivity of those within them in the Square Mile. Since the area is a major professional district it is essential that this impact is controlled.
	Rise in heat-related ill-health and mortality.	4	Limit increase in heat-related ill-health and mortality (visitors, residents and City Corporation asset users).	Temperatures rises are forecast to substantially increase heat-related mortality in future decades without action. Actions to cool areas in the Square Mile and City Corporation assets could have a major role in mitigating heat-related health risks.
3 – Risk of shortages in the public water supply, and for agriculture, energy generation and industry	Droughts/short term water shortage.	5	Increase community, public realm, open spaces and business preparedness for more frequent periods of droughts.	Droughts of high frequency and intensity will have a major impact on health and operations in the Square Mile and City Corporation assets and are of high likelihood in coming years.
	Longer term water shortages (residents, utilities and non-domestic uses).	6	Contribute to increasing water security by reducing projected supply and demand deficit.	Long-term projections indicate that water supply deficits may become an issue. As a local authority the City Corporation can play a substantial role in helping water suppliers ease the supply-demand gap for domestic and non-domestic consumption.
4 – Risks to natural capital, including terrestrial, coastal, marine and freshwater ecosystems, soils and biodiversity	Develop resilience in natural areas to a range of water stresses.	7	Protect and enhance natural areas during periods of drought and irrigation restriction.	Future water stresses will have consequences for the irrigation of the many natural spaces run by the City Corporation, among other risks (e.g. wildfire). Without action, the health and identity of these places could suffer significantly.
	Changes to terrestrial ecosystems.	8	Protect and increase natural spaces and Sites of Special Scientific Interest.	Under a high emissions scenario landscapes in the UK could shift towards having a substantially different environment, with substantial loss of species and biodiversity. [33] Similarly, aquatic systems will suffer from high temperatures and low water levels. The City Corporation runs several areas of parkland and water bodies, so is responsible for influencing resilience actions for these important areas.
		9	Protect and support terrestrial species populations and habitats (including new and target species).	
	Change to aquatic ecosystems, including lake and river habitats and species.	10	Protect and support aquatic species and plant populations.	
		11	Maintain and improve water quality in aquatic habitats .	

Table 5-1 Objectives of the Adaptive Pathways

05 Adaptive Pathway Planning

Risk	impact	Number	Objective	Justification for selection
5 – Risks to domestic and international food production and trade	Food (in)security due to price and production / distribution volatility (businesses and residents).	12	Reduce levels of food insecurity and food poverty in the Square Mile and in the City Corporation's wider asset portfolio.	Food insecurity and price volatility are likely consequences of global trade and agricultural shifts under a changing climate. The City Corporation is in a strong position to support businesses and communities to build resilience to these periods of upheaval through coordination, financial support and guidance. This work could be integrated with efforts by the City Corporation to tackle poverty as a whole.
		13	Support businesses and locals to withstand the consequences of volatile food prices.	
	Food shortages.	14	Support businesses and locals in times of food shortages.	It is possible that periods of food shortage will be experienced in the Square Mile, so it is essential that the Corporation explores where it can support residents and businesses during such events.
	Failure of wholesale food markets due to temperature or flooding risks	15	Prevent and mitigate adverse consequences of disruption to the wholesale markets as a result of changing climatic conditions and other risks	The wholesale markets are key infrastructure to London and the South East, and are managed by the City Corporation. It is essential that these operate effectively and their failure is mitigated and prepared for.
6 – New and emerging pests and diseases, and invasive non-native species, affecting people, plants and animals	Rise in plant and ecosystem diseases.	16	Minimise rates of disease proliferation in the Square Mile and City Corporation open spaces.	The City Corporation manages over 4,500 ha of natural space, so must be prepared to manage an increase in transmission and types of plant diseases and pest outbreaks.
	Rise in climate sensitive diseases and zoonotic diseases.	17	Work with health services to limit the spread and rise in climate-sensitive diseases.	As disease outbreaks, emerging infections and health risks evolve under a changing climate, new stresses and challenges may be experienced by Londoners and their health services. The City Corporation will explore how it can support resilience to such events.
	Rise in emerging infections and new zoonotic diseases.	18	Develop preparedness for disease outbreaks and changes in public health requirements.	
Cross-cutting	System-wide resilience in the Square Mile and City Corporation assets	19	Ensure resilience across City Corporation functions with changes in practice, governance and communications.	Adapting to embedding and facilitating better climate resilience will require numerous measures that relate to corporation governance, relationships with stakeholders and communications – this might include building internal City Corporation skills or cross-cutting emergency plans. These will be levers for all the risks and impacts covered in this study.

Table 5-1 Objectives of the Adaptive Pathways

05 Adaptive Pathway Planning

The City Corporation Adaptive Pathways

Overview

Within this section, the combined Adaptive Pathway is presented (Figure 5-3). This provides an overview of all proposed measures, their respective thresholds, indicative project lead times and associated trigger points over the next 60 years. The Adaptive Pathway provides detail on the broad variety of measure typologies – preparatory, mainstreaming, management and capital investment – and their area of influence – structural interventions, institutional measures or regarding social behaviour. A copy of the risk specific pathways has been included in Appendix C and should be referred to for further detail. The risk specific pathways illustrate at a high-level the key activities within the proposed measures. Further detail on each of the proposed measures can be found in Appendix D.

The measures presented have been developed through engagement with City Corporation officers. It has been identified previously that the programme of activities within each measure will require further development at subsequent stages. It is also proposed that measures to be taken forward are further refined through engagement with additional stakeholders. As such, it is proposed that the 39 measures presented are considered as possible actions; it should not be considered that each and all actions will be taken forward. In addition, we would expect these pathways to be updated in line with the National Adaptation Programme as new risks emerge, old risks are re-evaluated and new measures become available.

An analysis of prioritisation from the study is presented in Appendix A.

How to read the adaptive pathways

An example adaptive pathways diagram is shown in Figure 5-1. Each pathway (group of actions) is organised by its scheduling: some measures will require **ongoing** updates and rolling management, such as emergency planning, while others are immediate **preparatory** actions which will be undertaken over the short-term to build City Corporation resilience – such as strengthening water quality monitoring networks. Other measures are **adaptive**: the implementation of these measures will be dependent on a combination of the defined threshold, project lead time and associated trigger point. This threshold may change in time, for example changing planting regimes to match new environmental conditions will depend on our emissions trajectory.

The measures on the pathway diagrams are also annotated with key information such as their category and realm of influence. This could depend on the threshold being uncertain, or the results of an early stage review undertaken as part of the measure indicating it is not worthwhile to pursue further.

How to read the measures

The combined pathway consists of 39 individual measures. As outlined in the previous sections, these range from structural interventions to behavioural shifts, involve a multitude of stakeholders and possible collaborators, and for each measure, the City Corporation has a varying degree of influence and control.

Measures are summarised in the combined pathway (Figure 5-3) and key actions identified at a high level in the risk specific pathways (Appendix C). Further detail on each measure however has been provided in Appendix D. Within this a description of the need for each measure, and outline of its programme, with notes on key stakeholders and implementation requirements is provided. Details of its duration, relevant risks, associated co-benefits and costs are listed. In addition, a case study of comparative projects from other international cities has been provided. Table 5-2 provides a summary of the City Corporation departments and wider stakeholder responsibilities in the further refinement, development and implementation of adaptation and resilience measures.

An example of how this information is communicated in Appendix D is provided in Figure 5-2.

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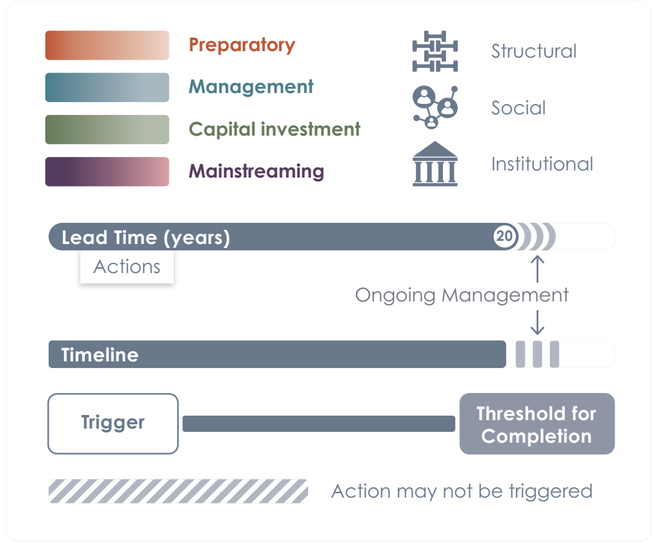
ADAPTIVE PATHWAYS

Example Pathway



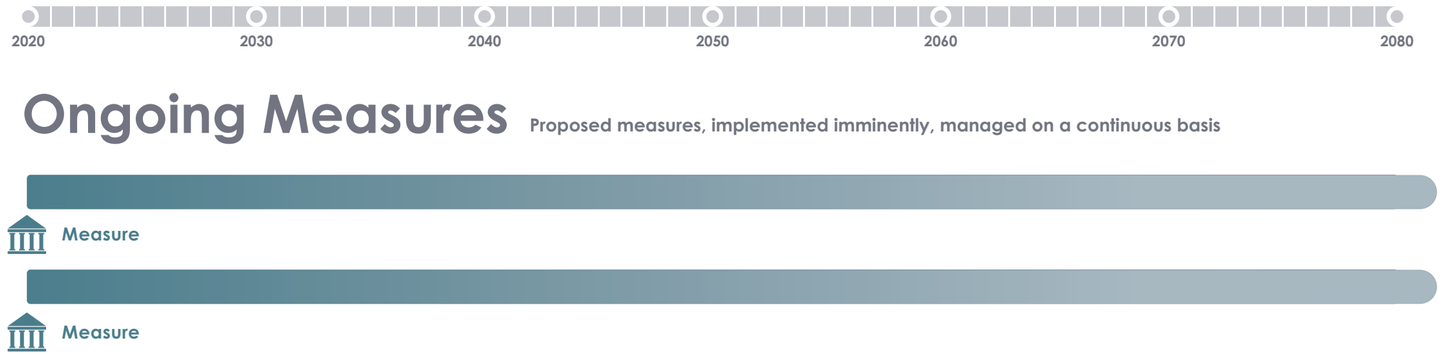


Figure 5-1 Annotated pathways diagram City Corporation adaptive pathways. The combined adaptive pathway is presented on page 24 and 25. The risk specific pathway can be found in Appendix C.

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RESILIENCE MEASURES

Building retrofit programme

Preparatory

Management

Capital Investment

Mainstreaming Initiative

Cross-cutting

Roll out a thorough programme of retrofits for residential and non-residential properties throughout the Square Mile and for those assets that the City Corporation are responsible. Retrofits should focus on ensuring assets are resilient to changing weather conditions and environmental patterns.

C40 Cities. (2020). The Multiple Benefits of Deep Energy Retrofits: A Toolkit for Cities.
www.c40knowledgehub.org

Why

Climate change poses multiple resilience risks at property-level. This includes rising temperatures raising the risk of building overheating in warm periods, rising sea levels and rainfall levels in winter heightening local flood risk, and increased frequency and intensity of extreme weather events posing threats to the building fabric and occupant safety. Conversely, management of properties also contributes to these risks: not only does fuel consumption directly cause climate change, consumption of water and contributions to the Urban Heat Island effect from the building design play a role in overheating and water stress.

What

Retrofits can be used to adapt structurally sound buildings in such a way that their influence on and risk from climatic changes are reduced, as seen in the list of retrofit measures supplied to the City Surveyors. In relation to resilience, risks associated with overheating and flooding are a primary concern. To address overheating, the introduction of shading and ventilation strategies may be considered. Replacing 'hardscaped' roofs with green or brown alternatives may have benefits for internal comfort and co-benefits for surface water management, external comfort and biodiversity. Flood protection measures may include additional water proofing, attenuation or even the reconsideration of finished floor levels or the introduction of temporary flood barriers. As part of resilience led retrofit efforts, interventions to reduce water consumption including in line with reducing availability of potable supplies should also be considered.

How

Resilience measures should be incorporated with the City Corporation's efforts to retrofit the existing building stock as part of their carbon reduction strategy, reducing costs and disruption. The Square Mile and areas beyond have a diverse building stock, so efforts should first start with understanding current levels of risk. Early retrofit actions should be focused on assets at high risk and/or where users are particularly vulnerable to impacts including social housing. Through its asset management strategies the City Corporation will also likely want to take early action on their own building stock, leading by example and showcasing what is expected of others. Funding could take place through the City Funds to support incremental increase in cost of asset management. Match funding from Re:fit and other invest to save finance funds should also be explored, and new government green schemes and opportunities promoted.

To tackle non residential buildings not owned by the City Corporation, action could be catalysed through a 'retrofit pledge' engaging business recognising that many corporates have their headquarters in the Square Mile, with many having already made declarations and commitments in relation to their environmental performance; the City Corporation should work with building owners and managers and wider business networks to show how resilience measures may be implemented within existing management regimes. The diverse nature of the building stock would require different technical strategies and approaches to be adopted; it is recommended the City Corporation share best practice of effective and viable measures for key architypes and produce design guidance which could draw on its own asset retrofit programmes. City Cash, Neighbourhood Community Infrastructure Levy's, Planning Obligations and third party loans are all potential implementation mechanisms for upgrading public buildings.

Risks addressed

- **Flooding**
- **Overheating**
- **Water stress**

Lead time

20 years

Objectives

1, 3, 4, 6

Co-benefits

1 2 **3** 4 5

Low High

Cost

1 **2** 3 4 5

Low High

Possible partnerships

- **GLA**
- **London Climate Change Partnership**
- **Practitioners**
- **Business Improvement Districts**
- **Resident and Business Forums**

Case Study: **The Multiple Benefits of Deep Retrofit, C40 Cities**

Large-scale urban retrofits require substantial upfront investments. To meet this investment need, city governments have to show exactly how a retrofit project will benefit the city as a whole to get sufficient buy-in from affected stakeholders and citizens. To support Cities in demonstrating this C40 Cities developed a methodology based on the growing body of evidence available to help cities quantify the co-benefits of retrofit. Piloted with New York, Milan, and Copenhagen, the study showed that potential benefits from deep energy retrofit: saving 3.4 MtCO2e; generating 34K - 52K jobs; reducing asthma by 2.9%; reducing energy poverty by 3.8%; and generating a net present value, across the pilot cities, ranging from USD 47.5 million to USD 659.2 million, associated with a payback time of 7 to 29 years. The toolkit provides cities with the evidence to make a compelling case for unlocking and accelerating the large-scale overhaul of urban building stock.

Links to existing City Corporation activities

- **Relevant parts of the emerging Climate Action Strategy,**
  records of previous retrofit strategies and cases in the Square Mile

Links to other existing policies, plans and guidance

- **London City Resilience Strategy, GLA**
  (Action B7)
- **Retrofit Accelerator, GLA**
- **Retrofitting London, London Climate Change Partnership**
- **Re:Fit programme for public buildings**
- **Deep Energy Retrofit Toolkit, C40 Cities**

Figure 5-2 Example of how the proposed climate adaptation and resilience measures are presented in Appendix D.

05 Adaptive Pathway Planning

Combined pathway

Figure 5-3 illustrates the breadth of measures proposed as part of the study. Given the cross-cutting nature of climate resilience and adaptation, measures selected are purposely a diverse mix of physical, institutional and social interventions. As set out within Section 3, during the selection of measures those that have been identified as effective both in terms of cost and outcome, have high co-benefits and are equitable have been prioritised.

There are a few key observations to make about the pathways:

1. Firstly, in order to begin building adaptive capacity in the short term, it is recommended that a number of ongoing preparatory, mainstreaming and management measures are adopted. It is anticipated that as opposed to establishing new programmes these may be integrated within the existing work streams and processes established by the City Corporation. Such measures include for example 'climate ready public health programmes'. The City Corporation already has an established strategy and plan in with regard public health (see the Joint Health & Wellbeing Strategy, 2017) though at present this has little reference to managing future health risks associated with climate change. It is understood that the Joint Health & Wellbeing Strategy is soon to be updated and this as such would provide a unique opportunity to ensure future iterations of the strategy incorporate measures related to future climate risks.

2. Secondly, it is recommended a number of preparatory measures are undertaken imminently. As set out in Appendix C, these represent important actions to be taken in the short term in order to build understanding and the evidence base to inform next steps, to work to ensure that development activities happening today are robust to future changes in climate and to ensure that appropriate financial support is available for the future role out of the plan. Such early actions will help to avoid risks of short-term decision making that locks in high, 'abortive' costs later.

3. There are a number of preparatory and adaptive capital projects that are recommended to be started in the short term. Preparatory capital projects primarily relate to no-regret opportunities such as the protection of critical infrastructure and sensitive assets, though investment in building the knowledge, skills and capacity of the City Corporation's climate resilience team is also recommended. The adaptive capital projects are required as the defined thresholds have already been reached, based on the UKCP18 and wider data reviewed. Such suggested measures include building retrofit and diversification of energy sources.

4. Finally, there are a few measures which may not need to be undertaken, or whose delivery should be completed by a threshold which may move in time. These represent measures which should be monitored closely and are part of the evolving, flexible nature of the plan. Many of these will need to be implemented imminently in order to be established in time for projected threshold dates – namely the cool streets programme, heat resilient roads and highways, and expansion of green cover. Others may not require implementation or will not require implementation for some time depending on circumstances, such as changes to planting regimes and flood management approaches.

5. In each typology, there are a number of 'cross cutting' measures which are essential for the delivery of measures in all risks, reflecting the intersecting nature of both the risks being tackled and the measures taken to tackle them. Several cross-cutting measures relate to public-facing initiatives: developing educational and guidance materials, good communication and facilitating networks and forums to engage with businesses and residents. The City Corporation Climate Action Strategy Survey for Square Mile businesses (Appendix A) corroborates the importance of these options: the majority of responses from organisations in relation to questions around the role of the City Corporation in mitigating resilience risks related to the need for dialogue, guidance and collaboration.

6. The pathways show a balanced approach to the six risks considered, with most risks tackled with comparable numbers of measures (see more analysis in Pathway design and development). The City Corporation Climate Action Strategy Survey for Square Mile businesses highlighted that while businesses felt more threatened by certain risks (namely Overheating and Pests & Diseases), they often felt less prepared for other risks (natural capital and food). This confirms the importance of the Adaptive Pathways strategy providing assurance to stakeholders by covering perceived critical risks while also supporting the development of those risks which are less well understood and managed at present.

7. Whilst the evidence base and our understanding of how the climate may change, and the implications this will have for physical, natural and social systems, is growing, it remains a complex science with much uncertainty. A common theme across the risk pathways is the need for further research as well as more effective integration of findings into strategies, plans and action, and dissemination to key stakeholder groups.

8. Table 5-2 provides a summary of the City Corporation departments and wider stakeholder responsibilities in the further refinement, development and implementation role of adaptation and resilience measures. Further detail on each measure proposed can be found in Appendix D. In latter sections of this report, recommendations are provided as to how the measures may be grouped into broad programmes of work to aid implementation.

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ADAPTIVE PATHWAYS

Combined Pathway

Preparatory
Management
Capital investment
Mainstreaming

Structural
Social
Institutional

Lead Time (years) 20

Actions

Ongoing Management

Timeline

Trigger

Threshold for Completion

Action may not be triggered

All Ongoing Measures Proposed

2020 2030 2040 2050 2060 2070 2080

- Mainstream climate resilience into City Corporation governance and decision-making
- Embed principles of inclusion and equity throughout all climate action strategies
- Public communications and awareness raising campaigns
- Emergency planning
- Review and expand data collection and monitoring across all properties to support decision-making
- Strengthen community and business networks to build adaptive capacity
- Develop financial package and programme to manage resilience actions
- Pest and disease horizon scanning, surveillance and research programme
- Strengthen resilience requirements for planning
- Introduce retrofit support, funds and prioritisation for vulnerable residents and those in affordable housing
- Climate-ready, fortified public health programmes
- Continue to fund flood modelling, which include SUDs and other mitigation strategies, to complement EA flood models
- Ports and markets operational resilience planning
- Action to tackle food poverty
- Enhanced monitoring, surveying and tracking of ecosystem health
- Support mutual aid and community aid groups
- Flood defence assets maintenance and management regimes

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CITY OF LONDON

ADAPTIVE PATHWAYS

Combined Pathway

Preparatory
Management
Capital investment
Mainstreaming

Structural
Social
Institutional

Lead Time (years) 20
Actions
Ongoing Management
Timeline
Trigger
Threshold for Completion
Action may not be triggered

Preparatory Measures

2020 2030 2040 2050 2060 2070 2080

A Review of above and below ground space utilisation in the Square Mile - 3 years, 2020 - 2023

B Expand use and availability of non-sensitive data - 4 years, 2020 - 2024

C Strengthen City Corporation skills and capabilities - 2.5 years, 2020 – 2023

D Sustainable rain and surface water management policies and implementation - 10 years, 2020 - 2030

E Protect key assets, critical infrastructure and sensitive equipment in flood zones - 15 years, 2020 - 2035

F Develop urban heat vulnerability index and mitigation strategy - 3 years, 2020 - 2023

G Strengthen water quality monitoring networks - 3 years, 2020 - 2023

H Develop City Corporation and Square Mile water footprint management strategy - 5 years, 2020 - 2025

I Establish research partnerships to inform future action planning and management of natural capital - 3 years, 2020 - 2023

J Explore and facilitate opportunities to promote regional food production - 4 – 12 years, 2020 – 2024, 2024 - 2036

K Open a City Corporation Ecological Research and Education programme - 6 years, 2020 - 2026

L Establish food 'waste' collection and redistribution system - 4 years, 2020 - 2024

M Model food supply networks through the Square Mile to inform future planning - 3 years, 2020 - 2023

N Emergency support package for food networks and businesses - 4 years, 2020 - 2024

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CITY OF LONDON

ADAPTIVE PATHWAYS

Combined Pathway

Preparatory
Management
Capital investment
Mainstreaming

Structural
Social
Institutional

Lead Time (years) 20
Actions
Ongoing Management
Timeline
Trigger
Threshold for Completion
Action may not be triggered

Adaptive Measures

2020 2030 2040 2050 2060 2070 2080

G Work with partners to accelerate actions to address water leak management
TW targets 50% reduction in leak-age by 2045

Flood risk already in place
H Introduce climate-resistant and adaptive landscaping
2071 conditions for Mediterranean planting (high emissions)

I Cool Streets Programme
32oC peak weekly tempera-ture and 36oC peak daily temperatures under high emissions scenario

33°C max daily temperatures already experienced
J Heat resilient public realm and highway surfaces

Flood risk already in place
26°C Tmax weekly overheating criteria surpassed
K Building retrofit programme

UKPN indicates flood-related risks to energy supplies are already significant and probably (all scenarios)
L Diversify energy sources and partner with regional organisations and utility providers to increase back-up power for critical services

M Extend function of public realm within fluvial and surface water floodplains as sacrificial land and/or develop into natural flood risk management areas
TE2100 plan divide

N Increase the quality and provision of green space and coverage in the Square Mile and wider City Corporation spaces
2043 Defra 25y plan target deadline

05 Adaptive Pathway Planning

Measure ref.	Measure name	City corporation department								External Stakeholders		
		City Surveyors	Department of the Built Environment	Innovation and Growth	Environmental Services	Community & Children's Services	Open Spaces	Town Clerks	Markets and consumer protection	Residents	Business	Supporting Service Other stakeholders
1	Action to tackle food poverty					X				X		X
2	Building retrofit programme	X								X	X	
3	Explore and facilitate opportunities to promote regional food production						X					
4	Climate-ready, fortified public health programmes					X			X	X		X
5	Continue to fund flood modelling, which include SUDs and other mitigation strategies, to complement EA flood models		X									X
6	Cool streets programme		X				X			X	X	
7	Develop City Corporation and Square Mile water footprint management strategy	X	X							X	X	X
8	Develop financial package and programme to manage resilience actions			X	X							
9	Develop urban heat vulnerability index and mitigation strategy	X		X		X				X		
10	Diversify energy sources and partner with regional organisations and utility providers to increase back-up power for critical services		X	X	X		X					X
11	Embed principles of inclusion and equity throughout all climate action strategies							X	X	X		
12	Emergency planning		X	X		X		X	X	X	X	X
13	Emergency support package for food networks and businesses		X	X	X	X					X	

Table 5-2 Roles and responsibilities in the refinement, development and implementation of proposed adaptation and resilience measures

05 Adaptive Pathway Planning

Measure ref.	Measure name	City corporation department								External Stakeholders			
		City Surveyors	Department of the Built Environment	Innovation and Growth	Environmental Services	Community & Children's Services	Open Spaces	Town Clerks	Markets and consumer protection	Residents	Business	Supporting Service Other stakeholders
14	Establish food 'waste' collection and redistribution system	X	X						X	X	X	X
15	Expand use and availability of non-sensitive data		X	X	X	X	X	X				X
16	Extend function of public realm within fluvial and surface water floodplains as sacrificial land and/or develop into natural flood risk management areas.		X				X			X	X	X
17	Flood defence assets maintenance and management regimes	X	X							X	X	X
18	Heat resilient public realm and highway surfaces		X									X
19	Strengthen community and business networks to build adaptive capacity			X		X		X		X	X	
20	Increase the quality and provision of green space and coverage in the Square Mile and wider City Corporation spaces						X					
21	Introduce climate-resistant and adaptive landscaping						X					
22	Introduce retrofit support, funds and prioritisation for vulnerable residents and those in affordable housing	X		X						X		
23	Mainstream climate resilience into City Corporation governance and decision-making							X				
24	Model food supply networks through the Square Mile to inform future planning			X					X	X	X	
25	Open a City Corporation Ecological Research and Education programme			X			X	X				
26	Pest and disease horizon scanning, surveillance and research programme			X								X

Table 5-2 Roles and responsibilities in the refinement, development and implementation of proposed adaptation and resilience measures

05 Adaptive Pathway Planning

Measure ref.	Measure name	City corporation department								External Stakeholders		
		City Surveyors	Department of the Built Environment	Innovation and Growth	Environmental Services	Community & Children's Services	Open Spaces	Town Clerks	Markets and consumer protection	Residents	Business	Supporting Service Other stakeholders
27	Ports and markets operational resilience planning								X		X	
28	Protect key assets, critical infrastructure and sensitive equipment in flood zones	X									X	X
29	Public communications and awareness raising campaigns					X		X		X	X	
30	Establish research partnerships to inform future action planning and management of natural capital						X					
31	Review and expand data collection and monitoring across all properties to support decision-making	X	X			X				X	X	
32	Review of above and below ground space utilisation in the Square Mile	X	X				X			X	X	
33	Enhanced monitoring, surveying and tracking of ecosystem health						X					X
34	Strengthen City Corporation skills and capabilities	X	X	X	X	X	X	X	X	X	X	X
35	Strengthen resilience requirements for planning		X							X	X	
36	Strengthen water quality monitoring networks	X	X				X					X
37	Support mutual aid and community aid groups					X		X		X		
38	Sustainable rain and surface water management policies and implementation		X				X			X	X	
39	Work with partners to accelerate actions to address water leak management	X	X					X				X

Table 5-2 Roles and responsibilities in the refinement, development and implementation of proposed adaptation and resilience measures

05 Adaptive Pathway Planning

Risk specific pathways

The following sections detail how the full list of measures in the combined pathways impact individual risks, providing an insight into how the objectives in Table 5-1 are met. Many of these measures have benefits for more than one risk, reflecting the tightly integrated and flexible design of the plan. The risk specific pathways can be found in Appendix C. A write up of each of the measures proposed can be found in Appendix D: in this write up the objectives that each measure supports is clearly identified.

Risk One: Flooding and coastal change risks to communities, businesses and infrastructure

Flood risk management will be continued in a similar manner to today, with maintenance of assets, flood modelling studies and planning regulations scaled on a rolling basis alongside new funds to support installation of property-level defence measures for vulnerable populations. In addition, numerous actions will be undertaken to build future preparedness: the development of a water management policy and open space resilience innovation, alongside retrofit programmes and protection for critical and sensitive assets in flood zones. In future it may be necessary to more radically alter flood management practices depending on iterations of the TE2100 plan; decisions regarding this are expected around 2050.[18]

Risk Two: Risks to health, well-being and productivity from high temperatures

A number of cross-cutting and ongoing measures will be particularly crucial with regard managing the risk of overheating. For example, embedding climate impacts in the Joint Health & Wellbeing Strategy or development of heat vulnerability indices. Such measures will be particularly crucial for delivering inclusive action and protecting the health of vulnerable populations may be disproportionately affected by the impacts of overheating. Many measures to tackle overheating should be implemented in line with temperature rises experienced and projected in the coming decades. Based on the defined thresholds, it is recommended that action to retrofit properties starts immediately, a cool streets programme may be triggered in the next five years, whilst action to diversify energy sources due to heat-related disruption may not be required until around 2060.

Risk Three: Risk of shortages in the public water supply, and for agriculture, energy generation and industry

Immediate actions to tackle water stress include planning, research and monitoring to better understand water systems and usage in the Square Mile. These will then inform more substantial measures, which could include leak reduction programmes, diversification of energy supplies, which are affected by water stress through cooling, and climate-resilient planting.

Risk Four: Risks to natural capital, including terrestrial, coastal, marine and freshwater ecosystems, soils and biodiversity

Natural Capital is essential for building an integrated climate and biodiversity approach to resilience. In addition to accelerating actions to increase green space through SUDs, for example, identifying growing opportunities and setting up programmes to better support community planting initiatives, a key short-term focus of the pathway is building on existing data collection, reporting and research efforts. These efforts will be vital in being able to robustly understand the impacts of climate change on natural capital assets in the future, and in turn informing the most effective course of action. As part of the preparatory measures an Ecological Research and Education Programme is Proposed, this could have benefits for raising community awareness as to the value of natural capital, for the propagation of species that may be fit for future climates and for facilitating a seed library that could provide community benefit. Adaptive measures around such as increasing green space cover will likely be required in the short term and, though measures such as climate-resilient planting may not be necessitated for a number of years, the City Corporation are beginning to integrate this measure into the management of existing and creation of new open spaces.

05 Adaptive Pathway Planning

Risk Five: Risks to domestic and international food production and trade

Measures to build resilience of food infrastructure in the Square Mile and City Corporation assets reflect the City Corporation's combined roles as a port health authority, asset owner and local authority. Tackling food poverty is proposed as a key ongoing action for investment. This may be supported by a number of other actions such as better management of food waste, modelling of supply chains and regional growing schemes but given the systemic nature of the risk, an overarching programme to tackle food poverty is viewed as key. Operational resilience planning of ports and markets will be vital given the role of these in London's food supply chain network. No adaptive measures have been identified at this stage of the study. Adaptive measures will be likely be necessary and be defined in future updates of this strategy by the City Corporation; this however requires further development of the evidence base and this will be achieved through the actions set out in this pathway.

Risk Six: New and emerging pests and diseases, and invasive non-native species, affecting people, plants and animals

The City Corporation will pursue several areas in order to build resilience to increasing risks from pests and diseases. This will include taking action to support grassroots groups (mutual aid) and strengthen healthcare programmes, while also undertaking regular horizon-scanning exercises and research programmes to better understand the risk landscape. Alongside this, measures around water management and natural capital control will be designed to incorporate an understanding of risks from pests and diseases – for example strengthening the natural capital planning strategy must take place with budgeting and activities planned to combat pest outbreaks and to support vulnerable species. Adaptive measures will be likely be necessary and be defined in future updates of this strategy by the City Corporation; this however requires further development of the evidence base and this will be achieved through the actions set out in this pathway.

Analysis

As set out previously, the measures proposed within the pathways may be further refined by the City Corporation, it is anticipated that through this process some measures may not be taken forward. In order to help inform future decisions regarding which measures are taken forward, a high-level analysis of the proposed measures has been included in Appendix A.

05 Adaptive Pathway Planning

Cost analysis

A preliminary high-level costing exercise to assess the order of magnitude cost requirements of the proposed measures has been undertaken, the outcomes of which are summarised below. The methodology and key assumptions made can be found in Appendix A, the key points of which are:

1. An estimated total cost of all proposed resilience and adaptation measures, attributable to the City Corporation, is presented derived from top down estimates of likely budget requirements. All costs are nominal and do not account for inflation.
2. The majority of measures have been costed using broad cost bandings and the proportion of costs attributable to the City Corporation for each measure has been assumed.
3. Further feasibility and appraisal work is required to assess the intervention options for measures and quantify the direct and indirect economic, social and environmental costs and benefits so that the wider benefits are understood. The outcomes of this work will inform decision making around which options go forward.
4. The total cost is presented over the UK National Adaptation Program periods for both a low and high emissions scenario (based on the pathways presented elsewhere in this study).
5. Total costs exclude costs which may be attributable to others but may be necessary for the successful implementation of proposed resilience and adaptation measures.
6. Costs presented in this study are high level and have been provided for illustrative purposes only. They have been developed with limited input from the City Corporation and others undertaking studies as part of the Climate Action Strategy. Costs have not been based on actual scheme and budget benchmarks from previous and planned projects based on the availability of data and timeframes for the project.
7. The cost estimate information may include a degree of overlap and double counting for some measures rather than reflecting the incremental cost of climate adaptation and resilience action. A further detailed cost assessment of each measure will be required during subsequent stages. Cost presented at this stage should be treated with caution and will be subject to future changes.

The outcomes of the cost assessment are illustrated in Table 6-3 below. The outcomes of this high-level assessment suggests a total programme cost of between £ 904 million and £1 billion between 2020 and 2052. The City Corporation are already taking action to adapt and build resilience to climate change. As such, it is believed that a proportion of this cost can be delivered through existing budgets and expenditures typically already incurred by the City Corporation. When accounted for, the high-level analysis suggests an additional investment of between £509 million and £621 million may be required across the whole programme life cycle 2020-2048. As set out within latter parts of this report, the funds required for implementation may be raised in multiple ways blending a range of sources of finance.

The assessment assumes that high emission and low emission pathways have the same distribution of costs across the different UK National Adaptation Plan periods. This is based on the pathways presented earlier in this report. A tool has been developed and shared with the City Corporation so that updates to the costs scenarios can be explored as further research around thresholds emerges, divergence between the emission pathways can be accounted for. Comparison between high and low emission pathways can be done by adjusting percentage distribution across the different UK National Adaptation Plan periods.

Table 6-3 Summary of cost analysis outcomes

High and low emission pathway costs (range)						
Total cost	**2018 – 2023**	**2023 - 2028**	**2028 - 2033**	**2033 - 2038**	**2038 - 2043**	**2043 - 2048**
£ 904,376,042- £ 1,085,468,397	**£ 76,509,034- £ 128,292,804**	**£ 198,321,495- £ 250,949,506**	**£ 194,859,426- £ 231,079,557**	**£ 181,059,440- £ 199,762,922**	**£ 126,813,323- £ 137,691,805**	**£ 126,813,323- £ 137,691,805**
Total cost Excluding budgeted measures	**2018 – 2023**	**2023 - 2028**	**2028 - 2033**	**2033 - 2038**	**2038 - 2043**	**2043 - 2048**
£ 509,220,880- £ 621,032,083	**£ 24,671,094- £ 57,097,662**	**£ 108,804,169- £ 140,766,487**	**£ 107,459,772- £ 133,756,589**	**£ 95,059,784- £ 105,598,284**	**£ 86,613,030- £ 91,906,530**	**£ 86,613,030- £ 91,906,530**

05 Adaptive Pathway Planning

Implementation

Governance

The adaptive pathway methodology requires a shift from a static risk management approach to a more dynamic approach. The strategy should be considered as a 'living' document that enables this to respond to changing climate risk as well as patterns of vulnerability affecting the Square Mile as well as outlying assets for which the City Corporation is responsible.

This shift to a dynamic strategy may require new approaches to programme management to be considered. It is anticipated that this is something that the City Corporation will explore in the subsequent stages of Climate Action Strategies development. Clear ownership, roles and responsibilities will be vital to the success of the Climate Action Strategy, this must also be aligned with the City Corporations internal and strategic decision-making processes, the integration of which should be explored under the 'mainstreaming resilience' measure. Based on our understanding of the City Corporation at this time, roles and responsibilities similar to the below may be considered in the next steps of the strategy:

- Member sponsor: we anticipate that this would be a senior Officer or elected member of the City Corporation who is involved in and able to influence its detailed key decisions made by the City Corporation. It is not anticipated that this individual necessarily delivers the technical work, but they will be the top-level champion and sponsor for climate adaptation and resilience. They will sit on key strategic boards and be able to identify where and when the Environmental Resilience team need to be engaged within the context of the City Corporation's wider operations and strategic decision making. A sponsoring committee which can group and coordinate with members as appropriate may also be appropriate.
- Programme lead and integration team: team or individual responsible for the day-to-day management of the Adaptive Pathways Strategy implementation. They will be responsible for coordinating various technical inputs and ensuring the successful implementation of the overall strategy, as well as its integration with the broader Climate Action Strategy and related City Corporation activities. The City Corporation has an existing Environmental Resilience Team; we propose that this team is well placed to take on this role. Given the cross-cutting nature of climate adaptation and resilience, this individual / team must be well networked throughout the various directorates in the City Corporation.
- Technical leads network: the Adaptive Pathways Strategy considers a diverse range of risks and will require much cross-departmental collaboration, to avoid conflict and unlock opportunity. The City Corporation is well positioned with technical experts in the various strategy areas, from open spaces to public health. It is recommended that a technical expert is identified for each risk. They will have overall responsibility for the delivery and development of actions within the risk category and be responsible for the monitoring and reporting of performance / progress.
- Other sponsors: technical leads will be supported by the work of the directorates, ensuring the climate resilience is mainstreamed throughout the work of the directorates will be crucial. Equally, within each directorate the programme or technical leads may wish to identify key 'allies' - or sponsors - to ensure that there is a champion for climate resilience within each critical part of the City Corporation.
- Formation of a local Climate Action Partnership: a consultative forum comprising of community and business groups and other organisations should be established to coordinate community based and business activity to deliver the strategy from the bottom up and to provide a reference group to track implementation of the strategy. Terms of Reference should be drafted to decide remit. It could be chaired by the Member sponsor and programme lead. It could be aligned to an existing forum/committee if there was a close link to a relevant group.

As referenced throughout this study, partnerships will be vital to the successful implementation of the proposed resilience and adaptation measures. Key partnerships have been identified within the write up of the measures (Appendix D), though through the further development and refinement of this in later stages of the Climate Action Strategy additional strategic partnerships may be identified.

Partners identified are diverse and span multiple sectors. The role that the proposed adaptation and resilience measures necessitate partners to play also varies; in some cases this is an exchange of information, in others this is direct action (e.g. retrofitting buildings). Given the cross cutting and multi-agency nature of the risks there will also be a requirement to engage some organisations on multiple parts of the strategy. Similarly, it is anticipated that partnerships will be vital to other aspects of the Climate Action Strategy (i.e. pathways to net zero carbon).

It is recommended as such that the City Corporation develop a clear 'partnership engagement strategy' for the Climate Action Strategy. To inform this, Programme and Technical leads should identify where relationships with key partners exist already and the nature of these relationships. Gaps in existing strategic partnerships should be identified, both in terms of organisations engaged and input received from partners.

05 Adaptive Pathway Planning

Funding Strategy

Delivering the strategy comes with significant costs to the City Corporation over the short, medium and longer term. Acting now however is vital to avoiding higher future costs that may be incurred through not keep pacing with the level of change. As set out in the previous section, it is believed that a number of the measures within the plan can be delivered through budgets already committed by the City Corporation with amendments to the programmes that these fund, and thus at no or low net additional cost.

It is proposed that the City Corporation consider establishing a City Climate Action Fund. The purpose of the City Climate Action Fund will be to coordinate expenditure associated with the Climate Action Strategy, supporting the City Corporation to manage the series of programs proposed. It is anticipated that establishing a standalone fund will help to ensure that investment Figure for climate action is safeguarded and that committed funds can be used in the most effective way. This will enable funds to be managed for multi-year programmes and allow the City Corporation to deal with and plan for uncertainties.

Figure 5-4 illustrates how the City Climate Action Fund may be structured; this will be required to be tailored in subsequent stages to meet the specific needs of the City Corporation. It is envisaged that the City Climate Action Fund would draw upon a number of sources of existing funding and blend these with additional finance opportunities. The programmes have been designed in such a way that actions set out within the strategy can be clearly grouped and a direct source of funding identified to support the delivery of these. In the early years, the majority of funding may be drawn down from the 'climate readiness program', though this will evolve with time and the nature of the pathways.

As set out within Figure 5-4, a number of existing sources of funding may be drawn upon, for example:

1. City Cash This is an endowment fund built up over the last eight centuries. Its incomes are derived mainly from property, supplemented by investment earnings and the fund is now used to finance activities mainly for the benefit of London as a whole but also of relevance nationwide. City Cash presents an opportunity through which many of the measures proposed could be funded, notably delivering the strategy will require the development of further climate resilience expertise in the City Corporation. This may be supported through City Cash.

2. City Fund This Fund meets the cost of the City of London's local authority, police authority and port health authority activities. In addition, in common with other local authorities, it receives grants from central government, a share of business rates income and the proceeds of the local council tax. Over the short term there may be lower opportunity to direct finance from City Fund to climate resilience action, though this may change as these become mainstreamed into the local authority services.

3. Community Infrastructure Levy The Community Infrastructure Levy (CIL) is a charge on new development that is used to help fund the provision of infrastructure in the City of London. Infrastructure funded through the CIL in the City of London includes: flood defence and risk alleviation, public healthcare facilities, transport improvements and public realm enhancement. There is strong alignment between these investments and the measures proposed in the adaptive pathways.

4. Neighbourhood CIL CIL Regulations require that 15% CIL receipts be used to assist the delivery of infrastructure to support neighbourhood priorities. As above, projects funded through this may be well aligned to climate adaptation and resilience measures proposed, though work with community groups may be required to refine these and ensure co-benefits for climate adaptation and resilience are maximised without compromising the neighbourhoods intended primary outcome.

5. Planning Obligations Planning obligations (often called s106 agreements) are agreements with developers for the provision of, for example, affordable housing, local training and jobs, and site-specific mitigation measures. Agreements must be based on the content of the Planning Obligations SPD and any allocation of funding must be directed towards the mitigation of the impact of a development on the City and neighbourhood. The existing Planning Obligations SPD has limited reference to climate adaptation and resilience, though does contain requirements relating to training of local communities and transport which proposed measures may align with.

As part of the mainstreaming action proposed in the pathways, conditions associated with these funding sources may be tailored in the future to make climate resilience a key consideration when making funding allocations. This may be also true of the Capital Bids Process; an internal process by of which directorates may bid for capital funding predominantly derived from the CIL and other similar sources. Applicants must demonstrate how the funding will deliver on the priorities set out within the Corporate Risk Register and Corporate Plan. Given the alignment of climate adaptation and resilience initiatives with the City Corporations objectives of a flourishing society and thriving economy.

05 Adaptive Pathway Planning

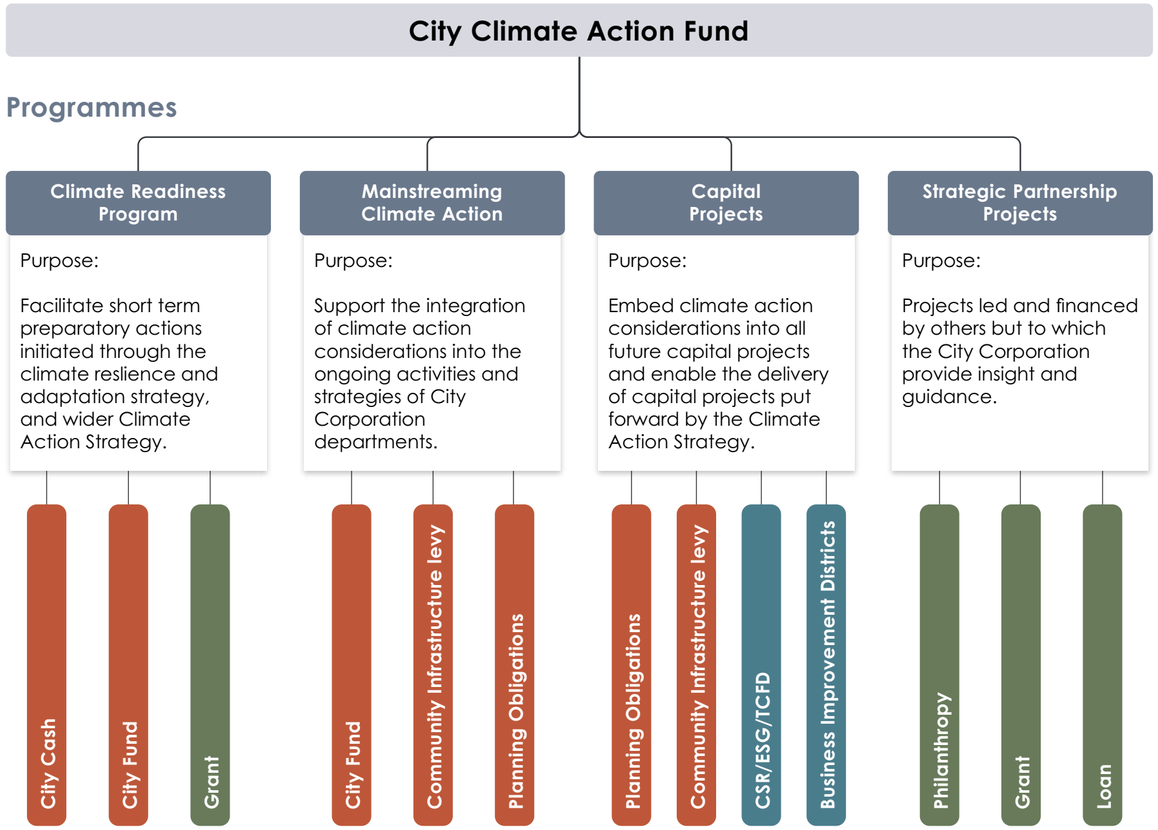


Figure 5-4 City Climate Action Fund, illustrative structure

Business Improvement Districts (BIDs) are also recognised as a key opportunity. BIDs are defined areas within which local businesses are required to pay an additional levy. The collected tax is invested locally to fund projects within the district's boundaries. Members of the BID decide how and where raised funds are invested, as such communicating the outcomes of the Climate Risk Assessment may create opportunities for supporting the implementation of measures set out within the adaptive pathways. Support for this approach is anticipated: in the City Corporation business Climate Action survey (June 2020, see Appendix A) all suggestions made by respondents for corporation action focussed on education, communication and facilitating networks for collaboration. Business Improvement Districts would be a structured, highly visible way to organise and provide this support.

The unique role of the Square Mile as a financial centre to the represents an opportunity to develop and showcase new financial and insurance-based solutions to climate change. This may for example consider the opportunities of working with TCFD (Taskforce on Climate-related Financial Disclosures) early movers to explore and pilot projects aligned with the aims of the Climate Action Strategy. Opportunities for raising additional funds could be sought through careful consultation with business and resident networks, and may include establishing voluntary funds supported by businesses that be drawn down from, or aligning business CSR (Corporate Social Responsibility) or ESG (Environmental, Social and Governance) activities with those of the Climate Action Strategy.

External finance opportunities may also be accessible to the City Corporation in order to raise funds to support the delivery of measures proposed through the adaptive pathways. For example, organisations such as the European Investment Bank offer a range of public and private sector loans. Such loans can be accessed for single large infrastructure projects or investment programmes containing a portfolio of smaller projects. Loans from the EIB, for example, are typically long term (sometimes exceeding 30 years) and may be blended with additional sources of investment. Opportunities to access funding from the UK Government may also be explored, for example the recently launched £200 million Sustainable Innovation Fund.

05 Adaptive Pathway Planning

Implementation levers

The City Corporation is a complex organisation of multiple directorates and many multi-agency partnerships. The City Corporation is responsible for a diverse population and asset stock, over which it has varying levels of control and influence and in turn a complex set of levers for influencing action. To ensure the successful delivery of the Climate Action Strategy, and particular adaptation and resilience efforts, it is necessary to identify those key levers to ensure that action can be unlocked and that those operating within the Square Mile and beyond are supporting the City Corporations climate action ambitions.

Through this study, the Corporate Risk Register and Joint Strategic Needs Assessment have been identified as key levers. These documents provide the evidence base for key strategies and plans developed by the City Corporation (e.g. the Joint Health & Wellbeing Strategy) and are key in informing where and how funds are spent. It is recommended that the City Corporation consider the integration of climate action (mitigation, adaptation, resilience, and sequestration) into these documents.

The following short-term opportunities have also been identified:

1. The City Corporation is currently consulting on an update 2014 Planning Obligations SPD. This presents a unique opportunity to influence future development proposals across the Square Mile, ensuring that these are future climate ready and that funds raised through s106 can be used to further climate action efforts of the City Corporation.
2. It is understood the 2017 Joint Health & Wellbeing Strategy will be updated over the course of the following 12 months. Climate change will have cross-cutting impacts for public health, and it is recommended that climate action is embedded throughout the revised strategy.
3. The City Corporation recently released a revised Transport Strategy. A number of the priority actions within this are aligned with the proposed measures of the adaptive pathways. The opportunity to accelerate action in these areas should be taken.
4. A COVID-19 response plan is currently being delivered by the City Corporation, funded through City Cash. Opportunities to embed principles of climate adaptation and resilience into the action being taken should be identified, especially so more permanent interventions proposed.

There is an opportunity to take early broad-based action in parts of the Square Mile undergoing change, particularly the Key Areas of Change identified in the Draft Local Plan 2036. These may present a unique opportunity to demonstrate good practice in tackling climate risk as well as mitigation and sequestration opportunities at a broader scale with the opportunity for the City Corporation to be a pathfinder and role model for the rest of London and other major cities.

Monitoring progress and strategy review

In line with the dynamic, living nature of the approach, effective management will underpin the success of the adaptive pathway strategy. Climate change is a complex science. There is much uncertainty as to how the climate will change over the coming decades and in turn the impacts that may be anticipated. This study has been grounded in the best available science and sets out how the climate may change under a low and high emission pathway, RCP 2.6 and 8.5 respectively. In reality, it may be unlikely that future emission trajectories follow that of either pathway.

As such, establishing a robust set of monitoring criteria will be vital in order to track climatic changes and potential impacts relative to the trigger points and thresholds set out within the adaptive pathways. This will support the City Corporation in tracking effectiveness implemented measures as well as identifying when decisions need to be made to ensure the Square Mile remains resilient. A preliminary set of indicators and monitoring criteria have been set out in Appendix E.

It is recommended that the strategy is monitored annually to support prioritisation and budgeting for the forthcoming year. The strategy should be reviewed every 5 years, in line with the UK National Adaptation Plan.

05 Adaptive Pathway Planning

Risks for implementation of the Adaptive Pathways

The Adaptive Pathways study has been developed using robust data and a structured, logical design approach. The use of Adaptive Pathways also makes the work more flexible and responsive to possible future changes in climate and risk, meaning it is a powerful tool for resilience planning, and it is expected that the measures recommended here can substantially increase the resilience of the Square Mile and City Corporation assets if implemented effectively. However, there are some key areas which may affect the successful implementation of the strategy and proposed measures:

- Funding: the Adaptive Pathways contain nearly 40 measures, each of which involves numerous subset actions, stakeholders and degrees of uncertainty. While some measures may not need to be implemented if a low global emissions pathway is achieved, these make up a small portion of the overall pathways given the high likelihood of risks occurring regardless of emissions trajectories at this point. An outline funding strategy has been proposed, securing the financial backing required to deliver the wide ranging and diverse combination of actions proposed will be vital to success.
- Governance: the City Corporation organisational and portfolio structure is highly diverse and spreads over a large, non-uniform geographical area. Careful management will be required in order to ensure that implementation is coordinated, effective and that the benefits of action taken are inclusive and equally distributed. Additionally, the need for member buy-in within the City Corporation structure to deliver policies and actions may introduce additional complexity to delivery.
- Political changes: the Adaptive Pathways study and City of London Corporation Climate Action Strategy sit in a broader landscape of policy requirements and local plans – namely those delivered by government departments and the GLA. Changes to these requirements have and will continue to move quickly in future decades as a result of growing public attention to the issue and increasingly visible impacts of climate change. These should support the measures suggested here, but action will be needed to ensure that the Adaptive Pathways align with broader policy changes and that additional requirements and opportunities are captured.
- City Corporation leadership changes: the actions proposed within this strategy are typically long term, in some cases it is recognised the measures proposed may take decades to deliver. Similar to the points made regarding policy change, it is likely that over the course of this strategies implementation, as well as the Climate Action Strategy there will be change in leadership within the City Corporation. Engagement with City Corporation leadership will be vital to ensuring the longer-term sustainability and success of the plan.
- Partnerships: the delivery of the Adaptive Pathways relies heavily on partnerships since many of the risks considered cut across different sectors with a wide variety of stakeholders. The ability to secure partnerships with effective results is vital to the successful delivery of the programme This may challenging at a time when numerous local authorities and other stakeholders are also likely to be looking to engage with major stakeholders. A clear ‘partnership engagement strategy’ for the Climate Action Strategy will be vital to ensuring effective engagement.

06 Conclusions and next steps

Conclusions

The urgent need for climate action is clear. Positive action to reduce carbon emissions is vital. Yet, even the most ambitious carbon reduction scenarios will result in climate impacts. The human, environmental and economic imperatives for building resilience and adaptive capacity are well established. By taking decisive action now and having a clear framework for the future, the Square Mile and the City Corporation's assets across London will be environments where people and businesses can thrive for generations to come.

The Square Mile and City Corporation assets are vulnerable to numerous climatically-influenced impacts. Many of these – such as flooding, overheating, water stress and risks to biodiversity – mirror those faced across the UK, and are directly influenced by changing weather patterns. For the Square Mile this could involve milder winters, with 20% more rainfall, and drier summers with daily temperatures increasing by nearly 5°C compared to a 1980-2000 baseline. However, the Square Mile is also dependent on regional and global systems that may be subject to more complex climatic changes. Rates of transmission and spread of pests and diseases may alter substantially in future decades, as could agricultural production and supply chains, with evolving weather and climatic conditions.

The City Corporation has already made significant progress in adapting to the changes at hand following the 2010 Climate Change Adaptation Strategy. This includes the development of planning regulations for property-level resilience measures, strong transport and biodiversity action plans to manage streets and green spaces, and a wealth of research and internal expertise. There is further support from the rich policy landscape at local, regional and national level – including the GLA London City Resilience Strategy 2020,[8] UK CCC Climate Risk Assessment 2017 [12] and National Adaptation Programs.[13]

This study provides an update to the 2010 strategy by analysing and drawing insights from the latest MET Office climate projections. Based on the adaptive pathway methodology adopted, this document also provides the City Corporation with the basis of a dynamic, living approach for the management of climate resilience and adaptation planning going forward. It may be considered the first step, but as set out throughout this document will require ongoing and continual development in response to changing climatic conditions and scientific understanding of climate impacts for example.

This document is not intended to be an evidence base for specific measures but, based on the analysis of the UKCP18, identifies when action may be required and broad programmes of measures that may be appropriate for the City Corporation to pursue in order to build resilience to the six risks that underpin this study. In turn, the strategy presented identifies those necessary short-term actions and provides guidance on how these may be facilitated. It further establishes a guiding framework to ensure the City Corporation remains responsive to longer term risks and potentially more extreme future scenarios, such that carbon projections may be integrated into the strategic planning decisions and development horizons. Measures range from revising ongoing infrastructure management works to build resilience – such as maintenance of flood defences, retrofitting against changing weather conditions, and environmental health management at wholesale markets to specific climate adaptation measures – such as altering planting regimes to cope with hotter temperatures and greater levels of doubt, intervening in the public realm networks to lower temperatures through cooling measures and potentially redefining public areas as sacrificial land for flooding in future decades. A key acknowledgement within the strategy is that further research is required in some key areas and all measures will require further development prior to implementation; the findings of these studies should be fed into the continual update of the adaptive pathway framework.

Action to build resilience and adaptive capacity will require multi-agency working and cross departmental coordination. Similarly, so, there is significant diversity in the type of programmes proposed through this study. For example, capital works programmes such as building retrofit or highway replacements, through to social and institutional measures such as emergency response plans and public communication and education initiatives. This study has demonstrated that whilst delivering resilience and adaptation measures may have a high financial cost for the City Corporation, significant progress could be made through reviewing and more thoroughly embedding principles of resilience and adaptation into existing work funded by the City Corporation. Moreover, a number of external financial support mechanisms exist and may be accessed, whilst – as a leading financial centre – there may also be opportunity to develop and showcase new financial and insurance-based solutions to climate change.

To enable the ongoing management of the strategy and indeed to implement this, it will be vital for the City Corporation to establish what the appropriate governance structure for success looks like. Fundamentally, this will require a shift from a static risk management approach to a more dynamic approach in which, perhaps responsibilities and key roles are decentralised and distributed across City Corporation departments.

06 Conclusions and next steps

Next steps

The City Corporation plan to launch the Climate Action Strategy in 2020. This report is one of a number of studies which will inform the development of this. It is understood that the City Corporation will consult with resident, business and member forums on the outcomes of the studies commissioned to inform the Climate Action Strategy. Through this consultation the City Corporation will finalise the key components of the Climate Action Strategy that are to be taken forward.

Based on work undertaken to inform the production of this study Buro Happold have identified the following areas that is suggested the City Corporation should consider focusing upon in the subsequent stages:

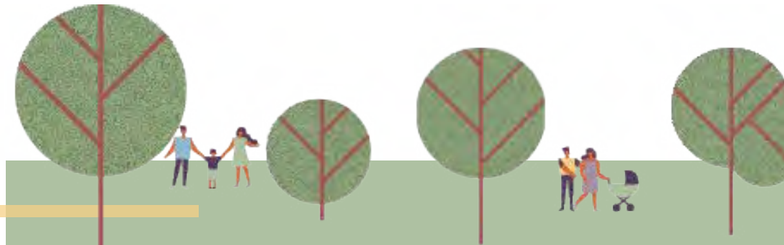
1. **Engage** The approach adopted to develop the content of this study has largely been 'top down'. There has been limited engagement with non-City Corporation stakeholders, notably businesses and residents, but also other public and private bodies. Engaging a wider range of stakeholders is recommended so that: 1) pathways can be refined to ensure that they are reflective of the priorities and needs of the diverse stakeholder groups, 2) early steps to enhance community business preparedness are taken, and 3) all stakeholders are bought into and understand the strategy, helping to ensure its effective implementation.

2. **Collaborate** Some measures within the pathways will require close cross-boundary and inter-agency working, particularly those to address flood risk, water scarcity and other climate risks with a close link to public health. The City Corporation will need to influence wider decisions and, working with others, will need to shape the strategic agenda to mobilise resources for those risks which require action beyond the Square Mile. As a key next step, it is recommended that the City Corporation test the plan with key interagency partners, with a view to refining this based on making the most of synergies and addressing any potential conflicts.

3. **Diversity** The assets and users of the Square Mile and for those beyond this boundary that the City Corporation is responsible, are diverse – be this the nature of assets; commercial, residential, new construction, refurbishment, heritage – as is the level of influence that the City Corporation has over each asset, or the acute needs and resources of those using assets. Processes of engagement and collaboration should take account of this diversity, helping to ensure the recommendations made are both representative and inclusive.

4. **Uncertainty** How the climate will change is a complex, and uncertain science driven by a great number of influences. This report has been based on robust, leading research in the field of climate science but the evidence base underpinning many of the assumptions made will continue to evolve. The adopted approach advocates for a shift from a static risk management approach to a more dynamic (adaptive pathway) approach. This enables the strategy to respond to changing climate risk as well as patterns of vulnerability within the Square Mile and beyond. As part of dynamic approach, ensuring the evidence base of this study is reviewed and refined is viewed as critical.

5. **Refinement** Linked to both the above ('diversity' and 'uncertainty') the purpose of this study has not been to define specific, detailed responses. As such the broad programmes set out within this strategy will require further planning and technical development, feasibility / viability testing and stakeholder engagement. Based on the outcomes of these activities, all elements of the pathways may be further developed and refined. It will be necessary to ensure that revisions to the pathways are continuously fed into programming and budgeting cycles, through the governance structure adopted.



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