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Adaptation actions in cities: what works?

Report of research findings

Committee on Climate Change

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Quality information

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1	3 August 2018	Final	No	Michael Henderson	Regional Director, Sustainability
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Cover image: Sustainable drainage feature installed at Queen Caroline Estate, London (credit: Groundwork)

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Executive Summary

The Committee on Climate Change (CCC) is an independent, statutory body established under the Climate Change Act 2008. The Adaptation Sub-Committee (ASC), which is part of the CCC, was also established under the Act to advise the UK government and report to Parliament on progress on adaptation to climate change.

In June 2017, the ASC produced its second statutory assessment of the National Adaptation Programme. This report considered what actions are being taken to adapt to the current and future impacts of climate change across a number of sectors, and how vulnerability to climate hazards is changing over time. A key finding was that, while much action is underway, it was in most cases unclear what impact those actions had had on reducing risk, i.e. vulnerability or exposure to climate change.

The ASC has commissioned AECOM Limited (AECOM) and Sniffer to collect evidence through a set of case studies in response to the following research questions:

1. How can we evaluate the impact on climate risk of adaptation actions or projects taking place in cities?
2. What characteristics of successful actions or projects may be transferable to other projects?

Findings of this study are based on 25 case studies across the urban areas of Glasgow City Region, Greater London, Greater Manchester, Leicester and Newcastle upon Tyne. While the majority of projects were led or supported by a local, combined or unitary authority, consideration was given to projects by any actor (e.g. private sector; National Government). Projects were also not required to be initially conceived of as 'climate adaptation'; in fact, the majority of projects were primarily framed around other drivers such as flood management or improving urban amenity.

Greater Manchester		Glasgow City Region		Newcastle		Leicester		Greater London	
GM1	Water Resilient Cities Pilot	**GL1**	White Cart - Phase 1 and 2, and Phase 3	**NE1**	Newcastle Helix	**LE1**	Leicester SuDS Programme	**LO1**	London Climate Change Partnership
GM2	City of Manchester: A Certain Future / Manchester Climate Change Agency	**GL2**	Seven Lochs Wetland Park and Green Network Strategy	**NE2**	Brunton Park Flood Alleviation Scheme	**LE2**	Leicester Flood Risk Management Scheme	**LO2**	Crown Woods Way
GM3	Roch River De-culverting	**GL3**	Climate Ready Clyde	**NE3**	Scrutiny Review	**LE3**	Hamilton Housing Area	**LO3**	Climate-proofing Social Housing Landscapes
GM4	Grow Green	**GL4**	Sighthill / North Glasgow Integrated Water Management System (NGIWMS)	**NE4**	Urban Flood Resilience / Blue Green Cities	**LE4**	ASDA SuDS Partnership	**LO4**	Lost Effra Project
GM5	Howard Street SuDS-enabled street trees	**GL5**	Rottenrow Gardens and Teaching and Learning Hub	**NE5**	East Pilgrim Street Redevelopment	**LE5**	Local Action Project Leicester	**LO5**	Thames Estuary Adaptation Pathways

Figure 1 Short-listed projects – blue cells denote case studies documented fully in Appendix B

Recommendations for project owners – key characteristics of successful adaptation projects

The following recommendations are based on findings from both research questions and should be considered by those seeking to implement adaptation projects:

- Fully map out a 'theory of change' using the framework of ***actions → outputs → outcomes → impacts*** at the project planning stage. Mapping expected causal relationships can help identify flaws in logic and reduce the likelihood of unintended consequences. It also helps with identifying the suitable indicators and metrics for monitoring and evaluation (M&E). This aligns closely with HM Treasury Guidance provided in its 'Magenta Book' and the C40 Urban Climate Action Impacts Framework.
- **Successful adaptation projects establish realistic timescales for development and delivery**. Large scale projects can require significant lead-in times, and innovative approaches naturally take longer to progress. This can be seen negatively by local authorities in particular; ongoing engagement is required to recalibrate the expectations of funders.
- **Adaptation projects should clearly identify where taking action can support delivering multiple benefits**, such as health, regeneration, and quantify these as far as possible. This may increase the chances of a project proceeding, relative to a proposal framed solely around climate change risk.

INCREASINGLY DIFFICULT TO PREDICT AND MEASURE
(a given action can have multiple outputs, outcomes and impacts)

Key construct	Action/activity	Output(s)	Outcome(s)	Impact(s)
	The work actually undertaken as part of a project. A given project can comprise many discrete and interrelated actions or activities.	What an action/activity actually produces. This could be physical (e.g. a new flood wall; a research paper), experiential (e.g. workshop attended by stakeholders) or virtual (e.g. an online tool).	The change(s) generated by output(s).	The consequences of an outcome or outcomes. The primary focus of this project has been the impact on risk, but actions may have a range of other impacts that do not specifically relate to risk reduction.
Worked example	Implement sustainable urban drainage features in schoolyards	Area de-paved (m^2)	Volume of water that can be effectively absorbed by the de-paved area in a 1-in-100 year rainfall event (m^3)	Extent to which the action has reduced exposure and sensitivity of the schoolyard to flooding.

Figure 2 Key monitoring and evaluation constructs

- **Seek early advice from specialists advice on issues such as tree selection for SDS schemes**. Quick guidance that improves the intervention's efficacy may often be available at little or no cost through universities or NGOs.
- **Project owners should map and understand stakeholders at an early stage**. Avoiding technical jargon is also important when engaging with the general public.
- **Involving NGOs can help smooth stakeholder engagement processes for council projects**. Several interviewees noted that having a third party undertake face-to-face engagement with stakeholders (e.g. door-knocking) may also have helped to circumvent potential reluctance among residents to engage with a borough council.

- **Securing political backing contributes to success**. Projects are more likely to move forward if high-level support can be secured from the outset either through backing by elected officials, or through championing the project at an executive level (or both).
- **Monitoring and evaluation should be central for novel or innovative approaches where effectiveness is not certain, or for more complex hazards such as heat**. Where a project's key aim is to demonstrate the value of a particular approach and encourage replication, M&E must be treated as an equally important aspect of the project and early effort should be taken to **establish a strong *ex ante* baseline**. More work is needed to mainstream M&E requirements into funding streams, particularly in relation to where projects deal with climate risks other than flooding.
- **Where budget available for formal monitoring is tight, seek opportunities to crowdsource data**. Advances in technology for citizen engagement are increasing the possibilities in this area.
- For partnership programmes:
  - **Making efficient use of stakeholders' time** is crucial for ongoing engagement. Be clear about the purpose of activities, make sure all those involved 'get something' from participating, and provide follow-up soon after events.
  - **Having the right staff and a well-connected, consultative chair is very important**, given staff resourcing is generally low (1-2 FTE).
  - **When engaging with businesses, partnership projects need to ensure their work is framed in a tangible and actionable way**. This may include presenting sector-specific business cases that demonstrate the potential for avoided costs and new opportunities. Given the size and variability of the 'business' community, more resourcing of partnerships may be required to tackle this comprehensively.
  - While it will not be the right model for all circumstances, **pooling the small discrete budgets of partner organisations can generate more adaptation progress than if these budgets are spent separately**.

Bishop Loch in the Seven Lochs Wetland Park - case study GL2 (credit: Collective Architecture)

Other key findings

- Of the 15 projects analysed in full, three were concluded with high confidence to have achieved the intended reduction in risk to date. Most projects could point to tangible outputs but **struggled to demonstrate their link with outcomes and impacts**.
- It is possible that projects may be better able to demonstrate impacts as more evidence becomes available over time. However, even where strong data does exist, it is often difficult to translate these into a conclusion about the level of risk reduction. The fact that few projects outside of flood mitigation schemes are initially framed around risk reduction contributes to this challenge, as typically **no baseline assessment has been undertaken using an agreed risk framework**.
- A combination of local climatic conditions and differing solutions makes comparing the risk reduction generated by projects challenging for hazards outside of flooding. More work is needed to develop a **framework that enables the comparison of risk reduction at local, regional and national scales**.
- For **low-cost projects** such as local SDS schemes, the cost of **a structured M&E programme will usually be prohibitive**. In these cases, proponents typically trust that outcomes will be in line with established design standards.
- Conclusions about the success of physical projects in reducing risk are **often made anecdotally** based on the observed consequences of a severe weather event. It remains difficult to draw decisive conclusions about the actual extent of risk reduction based on ad-hoc observations, particularly when these observations are based on a **limited number of unpredictable events**. However, it could be argued that as time grows since a project and the number of ad-hoc observations increases, so too does the evidence base become stronger.
- Funders should be encouraged to **request more information from project owners on outputs and impacts**. The research found that some funders require only basic information on project outputs; more successful projects such as 'Climate-Proofing Social Housing Landscapes' had a stipulation from the funder to evaluate and communicate the actual consequences of their activities and outputs.
- Cities should continue to **foster collaborative relationships with the Further and Higher Education (FHE) sector to accelerate and scale M&E**. Many are seeking opportunities to trial and refine technologies such as **remote sensing, internet of things and machine learning**. With costs progressively reducing, there is an opportunity to increase the number of projects gathering real time data and improving their understanding of project outcomes with the help of technology.
- The EU General Data Protection Regulation (GDPR) may present an **additional administrative and compliance hurdle** for any M&E exercises making using of 'personal data'. As the Regulation is new, it will be some time before the actual impact can be assessed.
- **Development and mainstreaming of tools and methodologies should continue to be encouraged and supported through research councils, industry bodies, and government requirements**. It can be difficult to quantify multiple benefits of adaptation projects, although in recent years CIRIA's Benefits of Sustainable Drainage Systems Tool (BeST) and tools developed through programmes such as Imperial College's Blue Green Dream project have made this type of analysis more accessible to project owners.
- **New funding and governance structures are needed to reduce siloed project design and delivery, encouraging holistic approaches that address climate risk alongside other policy agendas, such as improving health outcomes or place-making**. While holistic approaches may offer strong value for money, under present arrangements they can be challenging to fund, as the costs and benefits fall across different places across the public sector.
- **Providing core funding can help projects focus on delivering against their stated objectives**. The absence of core funding (e.g. to cover ongoing management) has, in some cases, required project owners to undertake an almost continuous process of seeking small grants, thereby reducing their capacity to focus on delivering climate adaptation interventions.
- **Government should consider how to de-risk development of funding bids for larger adaptation projects** and reduce barriers to cities accessing such funds. Some of the larger funding sources available for delivering adaptation, such as EU LIFE, involve **high levels of risk and reward**. Cities that are able to be flexible and responsive in bringing the knowledge and skills tailored to bid writing are more likely to attract resourcing.
- **Government should consider how to bridge the gap created from the departure of the EU**. Funding sources such as Horizon2020, EU LIFE and the ERDF played a key role in several projects. While the UK Treasury has outlined that some of these sources are to be underwritten for the current framework programme, there is no clear direction as to whether the UK will continue to be able to access these streams following its departure from the EU, or whether suitable replacements will be provided.

Glossary

Term	Definition
Adaptation	The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities.
Action/activity	The work actually undertaken as part of a project. A given project can comprise many discrete and interrelated actions or activities.
Adaptation project	In this study, an adaptation project can be a mix of different interventions (actions and activities) with the potential to moderate or avoid the risk of harm from severe weather events and climate change.
Adaptive capacity	The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.
Evaluation	A periodic assessment of the effectiveness and impact of a project in the context of the stated objectives.
Ex ante	Evaluation conducted before an intervention is implemented.
Ex post	Monitoring and/or evaluation conducted after an intervention is implemented.
Exposure	The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.
Impact	Medium or long-term consequences of an outcome or outcomes. The primary focus of this project has been the impact on risk, but actions may have a range of other impacts that do not specifically relate to risk reduction (e.g. improved amenity).
Indicator	Quantitative or qualitative factors used to measure change generated as a result of actions/activities.
Metric	Measurable (with units) expression of an indicator, e.g. particulate matter concentration in air (PM2.5 in parts per million).
Monitoring	An ongoing process of information gathering and review.
Outcome	Change generated by output(s).
Output	What an action/activity actually produces. This could be physical (e.g. a new flood wall; a research paper), experiential (e.g. workshop attended by stakeholders) or virtual (e.g. an online tool).
Risk	The potential for consequences where something of value is at stake and where the outcome is uncertain.
Sensitivity	Susceptibility to harm in the event of exposure to a hazard.
Vulnerability	The propensity or predisposition to be adversely affected. This is a function of sensitivity and adaptive capacity.

Table of Contents

1. Introduction

The Committee on Climate Change (CCC) is an independent, statutory body established under the Climate Change Act 2008. The Adaptation Sub-Committee (ASC), which is part of the CCC, was also established under the Act to advise the UK government and report to Parliament on progress on adaptation to climate change. The CCC and ASC are tasked with:

- Providing independent advice to government on setting and meeting carbon budgets in line with the UK's longer term target to reduce greenhouse gas (GHG) emissions by at least 80% by 2050 compared with 1990 levels, and reporting to Parliament on the progress made.
- Providing independent advice to the government on risks and opportunities to the UK from climate change, in part through the statutory UK Climate Change Risk Assessment, and reporting to Parliament on progress in adapting to climate change.

The ASC is required to undertake biennial statutory assessments of the National Adaptation Programme. These reports take stock of the actions being undertaken in the area of climate change adaptation and progress towards reducing vulnerability to hazards identified in the UK Climate Change Risk Assessment (CCRA).

In June 2017, the ASC produced its second statutory assessment of the National Adaptation Programme. This report considered what actions are being taken to adapt to the current and future impacts of climate change across a number of sectors, and how vulnerability to climate hazards is changing over time. A key finding was that, while much action is underway, it was in most cases unclear what impact those actions had had on reducing risk.

1.1 Study objectives

In 2018/19, the ASC plans to publish a series of reports focusing on the long-term adaptation outcomes for different areas in the UK and England: housing, land use, and the coast. To inform the reports on housing and land use, and the ASC's next progress report to Parliament in 2019, the ASC has commissioned AECOM Limited (AECOM) and Sniffer to collect evidence through a set of case studies in response to the following research questions:

1. How can we evaluate[1] the impact on climate risk of adaptation actions or projects taking place in cities?
2. What characteristics of successful actions or projects may be transferable to other projects?

Findings of this study are based on 25 case studies across the urban areas of Glasgow City Region, Greater London, Greater Manchester, Leicester and Newcastle upon Tyne (hereafter referred to as Newcastle). In addition to their strong levels of activity in the recent past around climate change adaptation, this mixture of cities was chosen to reflect different enabling environments (e.g. Greater Manchester is a Combined Authority; Leicester is a City Council; the model for Greater London is unique; Glasgow City Region operates under the Climate Change (Scotland) Act 2009), and a geographical spread.

While the majority of projects described in this report were led or supported by a local, combined or unitary authority, consideration was given to projects by any actor (e.g. private sector; National Government). Projects were also not required to be initially conceived of as 'climate adaptation'; in fact, the majority of projects identified and analysed in this study were primarily framed around other drivers such as flood management or improving urban amenity.

[1] 'Monitoring' and 'evaluation' are distinct concepts; while monitoring is an ongoing process of information gathering and review, evaluation typically occurs on a periodic basis ('ex ante': before the intervention; 'mid-term': during the intervention; 'ex post': after the intervention). The outputs of monitoring may form the evidence base for evaluation, and hence the two terms are often used together in this document (M&E).

Defining 'climate risk' for this study

This study accepts the UK CCRA's definition of risk as 'the potential for consequences where something of value is at stake and where the outcome is uncertain.'[2]

As 'adaptation projects' can vary widely approach (e.g. flood management schemes using physical interventions; training and awareness programmes), when evaluating case studies for their potential risk reduction impact, this study distinguishes between projects seeking to influence the different elements of risk as defined by the Intergovernmental Panel on Climate Change (IPCC) in its Fifth Assessment Report (AR5).[3]

- **Exposure**: The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.
- ***Sensitivity***: Susceptibility to harm.
- **Adaptive capacity**: The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.

Note that sensitivity and adaptive capacity are subsets of **vulnerability**, which is defined as 'the propensity or predisposition to be adversely affected'.

The 25 short-listed projects are listed in Figure 3 below. Further information on how these projects were selected is provided in Section 2.1. The notation (e.g. GM2, LE3) is used throughout the document when referencing findings from a specific case study.

Greater Manchester		Glasgow City Region		Newcastle		Leicester		Greater London	
GM1	Water Resilient Cities Pilot	**GL1**	White Cart - Phase 1 and 2, and Phase 3	**NE1**	Newcastle Helix	**LE1**	Leicester SuDS Programme	**LO1**	London Climate Change Partnership
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Figure 1 Short-listed projects – blue cells denote case studies documented fully in Appendix B

[2] Humphrey, K., and Murphy, J., (2016) UK Climate Change Risk Assessment Evidence Report: Chapter 1, Introduction. Contributing authors: Harris, G., Brown, S., Lowe, J., McCarthy, M., Jevrejeva, S., Watts, G., Johns, D. and Bell, M. Report prepared for the Adaptation Sub-Committee of the Committee on Climate Change, London.

[3] IPCC (2014) Emergent risks and key vulnerabilities, in: Climate Change 2014: Impacts, Adaptation, and Vulnerability, http://www.ipcc.ch/pdf/assessment-report/ar5/wg2/WGIIAR5-Chap19_FINAL.pdf.

2. Study approach

The methodology used to select and analyse case studies is summarised in Figure 4 below and described in more detail in the following sections.

	Glasgow City Region	Greater London	Greater Manchester	Leicester	Newcastle Upon Tyne
1. Select case studies	Generate long-list of case studies **(58)**				
	Filter using multi-criteria analysis and generate short-list **(25)**				
2. Data gathering	Desktop review of case study data				
	Desktop review of existing M&E practices				
		Semi-structured interviews with project owners			
3. Analyse individual projects		Assess actions, outputs, outcomes, impacts			
			Approach taken to M&E		
		Confidence that risk reduction has been achieved (high, medium or low)			
4. Cross-cutting analysis and reporting	Case study write-up **(3)**	Case study write-up **(3)**	Case study write-up **(3)**	Case study write-up **(3)**	Case study write-up **(3)**
	Thematic analysis – project success factors				
	Recommendations				

Figure 4 Project methodology

2.1 Select case studies

Five cities were selected collaboratively with the ASC Secretariat using the following criteria:

- The local and/or combined authority is willing to participate, a cooperative point-of-contact is known and has previously proven to be cooperative and eager to collaborate and share knowledge.
- Strong past and/or current activity around urban climate adaptation at the local and/or combined authority level, leading to projects that are complete or nearing completion.
- Other organisations/groups in the city are also active in the area of climate adaptation (e.g. private, NGO).
- The selected cities face a variety of key climate hazards broadly representative of those facing cities in the UK.
- The selected cities operate in a variety of legislative/governance contexts (e.g. Greater Manchester is a Combined Authority; Leicester is a City Council; the model for Greater London is unique; Glasgow City Region operates under the Climate Change (Scotland) Act 2009).

A long-list of case studies was then identified in each city selected. Projects were required to have a potential impact on severe weather and climate change risk, but they did not necessarily need to be conceived of specifically as 'climate adaptation'.

Project identification was undertaken in a collaborative manner with identified city representatives using the following steps:

- Initial teleconferences with city points of contact to discuss project aims and undertake preliminary identification of case studies.
- City points of contact consulted locally to identify and document basic information about case studies in a consistent template.
- The lists were supplemented with additional case studies identified through desktop research.

A short-list of five case studies per cities was then established with the aid of a Red-Amber-Green (RAG) matrix that sought to prioritise larger scale projects and/or projects with the potential for replicability, as well as projects at or nearing completion (to maximise the chances of monitoring data being available). The shortlists also sought to capture a mixture of approaches to adaptation (e.g. physical interventions vs capacity building and partnership working).[4]

[4] The Audit Commission (2005) defines 'partnership working' as 'an agreement between two or more independent bodies to work collectively to achieve an objective'. http://webarchive.nationalarchives.gov.uk/20150423154441/http://archive.auditcommission.gov.uk/auditcommission/aboutus/publications/pages/national-reports-and-studies-archive.aspx.html

2.2 Data gathering

2.2.1 Literature review

A literature review was conducted to understand a range of different approaches to evaluating the impact of climate change adaptation actions and inform the approach used in this study to evaluate if each project had achieved a reduction in risk. In total, 23 tools, frameworks and guides were reviewed – the details of these are included in Appendix A.

While there was variation in the terminology and approaches used across the different frameworks, it was possible to identify a series of overarching steps that were relatively common, as listed below. It is important to acknowledge that these steps represent an ideal scenario (e.g. project is clearly defined; a clear baseline was established; monitoring has been undertaken):

- Identify which element of risk the project is seeking to address: 'exposure' and/or 'vulnerability' (comprising 'sensitivity' and 'adaptive capacity').
- Map out the 'theory of change'. In other words, what is the thinking behind how taking a given action will have an impact on the level of risk? This broadly aligns with 'Magenta Book' guidance around establishing a project 'logic chains' and should give regard to expected causal relationships, including potential unintended consequences.
- Determine indicators to demonstrate the actions, project's outputs, outcomes and impacts
- Where the data is available, measure change between the baseline (*ex ante* – before the project) and *ex post* (after the project).

INCREASINGLY DIFFICULT TO PREDICT AND MEASURE
(a given action can have multiple outputs, outcomes and impacts)

Key construct	Action/activity	Output(s)	Outcome(s)	Impact(s)
	The work actually undertaken as part of a project. A given project can comprise many discrete and interrelated actions or activities.	What an action/activity actually produces. This could be physical (e.g. a new flood wall; a research paper), experiential (e.g. workshop attended by stakeholders) or virtual (e.g. an online tool).	The change(s) generated by output(s).	The consequences of an outcome or outcomes. The primary focus of this project has been the impact on risk, but actions may have a range of other impacts that do not specifically relate to risk reduction.
Worked example	Implement sustainable urban drainage features in schoolyards	Area de-paved (m^2)	Volume of water that can be effectively absorbed by the de-paved area in a 1-in-100 year rainfall event (m^3)	Extent to which the action has reduced exposure and sensitivity of the schoolyard to flooding.

Figure 5 Key monitoring and evaluation (M&E) constructs

2.2.2 Gather detailed information on case studies

For each short-listed project, publicly available information (e.g. project websites) was first sourced and reviewed. Following this, the identified point-of-contact for each project was invited to participate in a semi-structured interview via telephone. The following broad areas were covered in each interview (the full list of questions is provided as Appendix C):

- How the need for the project was identified.
- How the project was scoped, designed and funded.
- The level of stakeholder engagement undertaken.
- Methods used to track implementation progress of the project, as well as monitor and evaluate outputs, outcomes and impacts, particularly as they relate to risk.
- Challenges encountered during implementation and lessons learned.
- Key factors contributing the project success, including preconditions that allowed the project to go ahead.

Where required, follow-up calls and emails were exchanged. In some cases, interviewees were able to provide supporting documentation for review, such as project plans or monitoring reports.

At the end of the data gathering phase, a decision was made on the case studies in each city to be carried forward for full write-up. Projects were carried forward where sufficient data was made available; one project (LO5) was discounted as an appropriate interview subject could not be contacted in the time available. Although only 15 case studies have been analysed and documented fully in Appendix B, the outcomes of research into all 25 case studies inform the overall findings discussed in the body of this report.

2.3 Analyse individual case studies

The 15 remaining case studies were analysed individually to determine:

- The approach taken to M&E.
- Factors that may have contributed to, or inhibited, the project's success. In this study, success is interpreted first and foremost in terms of risk reduction, but success in other areas such as obtaining funding and achieving broader project objectives was also considered.
- Evidence available to demonstrate that project actions/activities have generated tangible outcomes and impact, including a reduction in risk associated with one or more climate-related hazard. Based on the evidence provided, each project was then rated in terms of 'Level of confidence that risk reduction has been achieved as a direct result of the project.'[5] (see Table 1)

2.4 Cross-cutting analysis and reporting

A key aim of this study was to understand commonalities and differences across the cities and case studies, with the aim of understanding:

- Potentially worthwhile approaches to evaluating the impact on climate risk of adaptation actions or projects taking place in cities.
- The characteristics of the successful actions or projects may be transferable to other projects.

This was undertaken through a series of thematic analysis conference calls with AECOM and Sniffer team. This was supported by desktop analysis of documented responses to each interview question, focusing on recurring topics and phrases. A review of the breakdown in project funding sources was also undertaken.

Key findings were agreed among team members on the conference call, which were then validated alongside publicly available research on M&E of adaptation impacts.[6] [7]

Confidence rating	Rationale
High	Quantitative evidence available to demonstrate outcomes and impact; or several sources of qualitative evidence available
Medium	Some qualitative evidence available to demonstrate outcomes and impact; or evidence of significant outputs that may have contributed to risk reduction
Low	Negligible evidence of outcomes and impact; difficult to attribute risk reduction outcomes to outputs

Table 1 Guidance on how confidence ratings for project risk reduction were assigned

3. Findings – evaluating the impact of adaptation actions

This section focuses on the ASC's first research question for this study: how can we evaluate the impact on climate risk of adaptation actions or projects taking place in cities?

Key findings – Section 3

- Of the 15 projects analysed in full, three were concluded with high confidence to have achieved the intended reduction in risk to date. Most projects could point to tangible outputs but **struggled to demonstrate their link with outcomes and impacts**.
- It is possible that projects may be better able to demonstrate impacts as more evidence becomes available over time. However, even where strong data does exist, it is often difficult to translate these into a conclusion about the level of risk reduction. The fact that few projects outside of flood mitigation schemes are initially framed around risk reduction contributes to this challenge, as typically **no baseline assessment has been undertaken using an agreed risk framework**.
- A combination of local climatic conditions and differing solutions, makes comparing the risk reduction generated by projects challenging for hazards outside of flooding. However, more work is needed to develop a **framework that enables the quantification of risk reduction at local, regional and national scales**.
- For **low-cost projects** such as local SDS schemes, the **cost of a structured M&E programme will usually be prohibitive**. In these cases, proponents typically trust that outcomes will be in line with established design standards. However, for **novel or innovative approaches**, or for more complex hazards such as heat, **more M&E is required to successfully establish confidence** in the design and delivery of measures.
- Given advances in technology for citizen engagement, there are **opportunities to crowdsource more data to inform M&E**.
- Conclusions about the success of physical projects in reducing risk are **often made anecdotally** based on the observed consequences of a severe weather event. It remains difficult to draw decisive conclusions about the actual extent of risk reduction based on ad-hoc observations, particularly when these observations are based on a **limited number of unpredictable events**. However, it could be argued that as time grows since a project and the number of ad-hoc observations increases, so too does the evidence base become stronger.
- Funders should be encouraged to **request more information from project owners on outputs and impacts**. The research found that some funders require only basic information on project outputs; more successful projects such as 'Climate-Proofing Social Housing Landscapes' had a stipulation from the funder to evaluate and communicate the actual consequences of their activities and outputs.
- Cities should continue to **foster collaborative relationships with the Further and Higher Education (FHE) sector to accelerate and scale M&E**. Many are seeking opportunities to trial and refine technologies such as **remote sensing, internet of things and machine learning**. With costs progressively reducing, there is an opportunity to increase the number of projects gathering real time data and improving their understanding of project outcomes with the help of technology.
- GDPR may present an **additional administrative and compliance hurdle** for any M&E exercises making using of 'personal data'. As the Regulation is new, it will be some time before the actual impact can be assessed.

[5] Sniffer, a contributor to this report, is also the managing agency of Climate Ready Clyde (GL3). To ensure objectivity, Sniffer personnel did not play a role in rating the effectiveness of this project in reducing risk.

[6] Bours, D., McGinn, C. & Pringle, P. (2014) Monitoring & evaluation for climate change adaptation and resilience: A synthesis of tools, frameworks and approaches, https://ukcip.ouce.ox.ac.uk/wp-content/PDFs/SEA-Change-UKCIP-MandE-review-2nd-edition.pdf.

[7] UNDP DTU Partnership (2016) Monitoring & evaluation for climate change adaptation: a summary of key challenges and emerging practice, http://www.unepdtu.org/-/media/Sites/Uneprisoe/Publications%20(Pdfs)/MandE-challenge-guidance-note_01-07-16.ashx?la=da.

3.1 M&E approaches used in case studies

Across the projects, a range of different approaches were taken to gather data and evaluate the consequences of a given project. These can be considered on a continuum through from projects that relied only on informal approaches to documenting outputs (e.g. number of personnel trained; square metres de-paved), through to structured approaches seeking to quantify the range of impacts of a given project (e.g. using monitoring data in an *ex post* cost-benefit analysis).

Based on the M&E data provided by project owners, for three of the 15 projects in Appendix B it could be concluded with 'High' confidence (GL1; LO3; LE2) that the intended reduction in risk has been generated to date. Two of these were large-scale flood risk management schemes, while one was a programme seeking to demonstrate the climate change adaptation benefits of sustainable drainage systems (SDS).

3.1.1 Documenting outputs

All project owners consulted were able to provide some understanding of the outputs generated through their activities. In most cases a numerical figure could be provided (e.g. 10 trees and two raingardens installed as part of project LO2); however, where the outputs were not physical (e.g. delivery of training sessions) there were many instances where the approach to record keeping made it difficult for project owners to quantify the output (i.e. number of personnel who attended the training session).

Several interviewees noted that assessing outputs (e.g. number of training sessions held) was often done retrospectively to complete mandatory funder reports. One interviewee also noted that funders they deal with typically asked for data on outputs and rarely required any information on the resultant outcomes (e.g. change in competency among those participating in training sessions).

For stakeholder engagement and capacity building activities in particular, few projects had gathered evidence to support firm conclusions about the resultant outcomes and impact. For example, the Manchester Climate Change Agency (MCCA) (GM2) contends that this engagement effort has created a more shared sense of responsibility for adaptation, shifting away from past assumptions that responsibility lies primarily with local government. However, while it has assembled evidence regarding outputs of its stakeholder outreach activities (over 100,000 people reached through its various communication and engagement channels; 10 international conferences hosted), less clear is the depth of engagement and the outcomes it has led to, particularly in terms of risk reduction.

However, this is not to say that the approach taken by MCCA is incorrect. Assessing the impact of stakeholder engagement and capacity building is highly resource intensive and dependent on the methods chosen – it is therefore entirely understandable that an agency such as MCCA may not prioritise this exercise. Instead, the MCCA draws actively on the guidance of reputable bodies such as the Global Covenant of Mayors and the European Climate Adaptation Platform (Climate-ADAPT) to inform its engagement approach. By following a 'best practice' resource, MCCA may be satisfied that its engagement activities are generating positive outcomes, even if it cannot point to evidence specific to the project.

3.1.2 *Ex ante* modelling

All schemes relating to construction of flood defences or SDS undertook some *ex ante* (i.e. before the project) evaluation of expected outcomes. In the majority of cases, such approaches are mandatory for qualifying for funding such as Flood Defence Grant in Aid. For small scale SDS schemes this involved simply designing the scheme to meet an accepted return period standard laid out in planning guidance (e.g. 1-in-100 year event plus a standard allowance for climate change). For some of the larger schemes, some analysis of the number of properties projected to have reduced exposure to flooding was undertaken (e.g. LE2 predicted to reduce flood risk to 217 properties in Phase 1 and 1,500 properties in Phase 2). While *ex ante* modelling does not confirm that the expected level of risk reduction has actually been achieved *ex post* (i.e. after the project), for most schemes there appears to be trust that adhering to design standards will result in the projected outcomes.

3.1.3 Ad-hoc observations based on severe weather events

In the absence of formal *ex post* monitoring, conclusions about the success of projects in reducing risk are often made anecdotally based on the observed consequences of a severe weather event. For example, the Roch River De-culverting project (GM3) points to the consequences of Storm Eva on Boxing Day 2015 as evidence of the effectiveness of the scheme in reducing flood risk. While the event did result in some property damage (business and residential) and transport disruption, it was reported that the scheme performed well and as designed in significantly reducing both the severity and the duration of the flooding event compared to major rainfall events that pre-date the project. Similar evidence was provided as part of the interview for White Cart (GL1).

For the Crown Woods Way scheme (LO2), ad-hoc observations by local residents have been welcomed as a low-cost way of monitoring its success. However, it remains difficult to draw decisive conclusions about the actual extent of risk reduction based on ad-hoc observations, particularly when these observations are based on a limited number of unpredictable events. However, it could be argued that as time grows since a project and the number of ad-hoc observations increases, so too does the evidence base become stronger. This may be the case of the Hamilton Housing Area project (LE3), which was an early application of SDS at a large scale during the 1990s. The interviewee reported that the project has been very effective in reducing flood risk for nearby properties, having withstood major storms over the intervening period. However, the ability to rely on ad-hoc observations over a long period can be adversely influenced by the likelihood of significant personnel change and potential loss of institutional memory.

3.1.4 Controlled trials of interventions

The Climate-Proofing Social Housing Landscapes project (LO3) was the only case-study that took a semi-experimental approach by undertaking a controlled trial of one of its SDS features. This involved project partner Thames Water providing a 10,000 litre tanker of recycled water, which was then pumped into a vegetated swale at a controlled rate simulating a 1-in-100 year flooding event, including a standard Environment Agency (EA) allowance for climate change. This enabled the project team to understand if the feature in fact performed in accordance with design specifications and supported the evidence base that the project was attempting to establish around the value of SDS (see Section 4.1.3 for further discussion). Such approaches are more common in the development of standards, or product testing such as BRE's new 'flood resilient home'.

Trialling a SDS feature in a 'simulated flooding event' (credit: Groundwork).

3.1.5 Real-time environmental monitoring ex post

Three projects on the long-list reportedly generated real-time environmental monitoring data as part of their M&E approach:

- In partnership with University of East London, project LO3 deployed a range of equipment to monitor the outcomes of the various SDS features installed on social housing estates in the London Borough of Hammersmith and Fulham. This included a weather station at each site, flow meters, pressure sensors and time-lapse cameras to monitor the effectiveness of the different types of feature in capturing water. Thermal cameras were also used to measure the effect on temperatures at a local scale; this was unique among the projects reviewed in this study. In addition to generating data on outcomes of different interventions, this enabled the project team to make small revisions to optimise their effectiveness. Refer to Section 3.1.6 for discussion on how this environmental data has been used in project evaluation.
- The White Cart flood risk management project (GL1) undertook real-time monitoring of water flow and volumes detained in flood storage areas upstream during storm events. This data was used to calculate the number of properties protected from flooding events of different magnitudes, with further analysis also undertaken to quantify the financial value of damage avoided and the effects on the capacity of property owners to obtain insurance. It was reported that, up to 2011/2012, the scheme had resulted in £20m of avoided damages alone.
- The SDS-enabled street trees project (GM5) used sensors and water quality monitors in tree pits. This data has not been seen by the team conducting this study, nor is it clear how it was used to evaluate the project's impacts.

Projects LO3 and GM5 both used universities to deliver the real-time monitoring; many universities (such as Newcastle University's 'Urban Observatory') are seeking opportunities to trial and refine technologies such as remote sensing, internet of things and machine learning. As the costs of deploying these approaches reduce with time, there is an opportunity to increase the number of projects gathering real time data and improving their understanding of project outcomes with the help of technology.

3.1.6 *Ex post* outcomes-based analysis

Two projects considered in this study deployed *ex post* outcomes based frameworks as part of their evaluation approach. This is likely due to their shared aims of demonstrating the value of sustainable drainage approaches with the aim of encouraging broader uptake.

For the Water Resilient Cities Pilot (GM1), cost-benefit analysis was viewed as the right mechanism to translate and quantify the broad range of benefits, which include reducing flooding risk on a local scale. The project used the publicly available Construction Industry Research and Information Association (CIRIA) Benefits of SDS Tool (BeST). The interviewee for this project indicated mixed success in using the tool to assess benefits; while benefits in areas such as property value, emissions mitigation and heat reduction were reportedly quite straightforward to quantify, benefits with a more social dimension required users to make more challenging assumptions and identify proxy indicators.

The proponents of project LO3 elected to apply a Social Return on Investment (SROI) model[8] to the project. It found that the project had generated between £2.31 and £5.15 for every £1 invested (note it is outside the scope of this study to interrogate the methodology and underlying assumptions made in the SROI report). The CIRIA BeST tool is also being used to evaluate the project's outcomes and impact over the longer term, taking into account additional factors not considered in the SROI such as reduction in crime, improvements in environmental education, and wider health and recreation benefits.

3.2 Challenges identified to monitoring and evaluating impact

A literature review undertaken by the United Nations. Environment Programme (UNEP)[9] has identified the following common conceptual challenges to M&E for climate adaptation projects, all of which have been applicable to projects considered in this study:

- The lack of a standard methodology or metric: there is no well-established 'best practice' M&E methodology and indicators for adaptation interventions, as is generally available for many non-climate change-focused development interventions. The widely varied nature of projects with consequences for climate resilience means it is unlikely that such a methodology will ever exist.
- Baselines and attribution: As adaptation is an additional factor in dynamic development processes and interconnected natural systems, defining specific *ex ante* baselines and directly attributing change to a given adaptation intervention difficult.
- Timing: Timeframes for the expected benefits of adaptation interventions are usually longer than the normal lifetime of standard projects and programmes. Where an investment seeks to build resilience to a severe weather event, it is difficult to predict when the benefit may be realised.

In addition to these conceptual challenges, the following practical issues have been identified through case studies.

3.2.1 Funding and resources

Constrained funding and staff resources have been identified regularly as barriers to delivery of successful adaptation projects (see Section 3.2.1). In such a resource-constrained environment, M&E is often one of the first aspects of a project where cost savings are sought. This is more likely to occur for small projects, such as the Crown Woods Way SDS scheme (LO2) – with a total project budget of approximately £20,000, it was indicated that a structured and comprehensive monitoring programme using appropriate analytical equipment could outstrip the cost of the scheme itself.

A counterpoint is the Climate Proofing Social Housing Landscapes project (LO3), which, as noted earlier, took an uncommonly rigorous approach M&E, which reportedly comprised 10-15% of its total project budget. This was partly a requirement to qualify for part-funding of the project through the European Commission's LIFE+ programme, as well as strong stipulations around the need for M&E as a condition of funding.

[8] Groundwork (undated) Life+ Climate-Proofing Social Housing Landscapes Social Return on Investment (SROI) Report), https://www.groundwork.org.uk/Sites/urbanclimateproofing/Pages/ucp-evaluation.

[9] UNDP DTU Partnership (2016) ibid.

However, despite the strong budget and generally rigorous approach to M&E, interviewees for this project noted that, in retrospect, a stronger baseline would have been available if monitoring had been commissioned to start earlier in the project. The slow start to monitoring meant that, rather than compare *ex ante* and *ex post* data from the same housing estate, it was often necessary to compare data from project estates to adjacent estates where no interventions had been implemented.

Partnership working programmes such as the LCCP (LO1) attempt to facilitate connections between disparate actors with potentially complementary roles to play in addressing climate change risks. Assessing the consequences of this work is a longitudinal exercise, as it may be several years before the connections facilitated through such programmes result in tangible outcomes (e.g. a completed project). Ideally partnership working programmes would devote more effort to longitudinal M&E; however, as described in more detail in Section 4.2, funding and staffing levels for partnership working programmes are typically low (e.g. 1 full-time equivalent for the LCCP). In this context it can be difficult to justify greater investment in M&E as it diminishes the time available to deliver the partnership's core activities.

3.2.2 Data management

Where projects involve multiple actors, relevant monitoring data is often held or owned by different parties and stored in different systems. Sharing this information can present challenges. In the case of the Science Central (NE1) project; it was suggested by the interviewee that those seeking to implement similar programmes should establish one easy-to-navigate information sharing platform at the outset, which can also be used as a project archive.

This issue can be further complicated by organisations' data security policies. The recent establishment of the General Data Protection Regulation (GDPR) (EU) 2016/679 also presents an additional administrative and compliance hurdle challenge for any M&E exercises making using of 'personal data' .[10]

3.2.3 Lack of appropriate skills and knowledge

Staff turnover and movement – which can be exacerbated by funding constraints – can also mean that climate change adaptation and resilience is not always the main or part of skillset of people managing the projects, and acts as a barrier to the effective documentation of necessary evidence of outputs and outcomes. This can result in confusion when monitoring and evaluating the impact of projects, as, understandable, risk language and constructs (e.g. the difference between 'outputs' and 'outcomes') can be poorly understood.

Additionally, it was reported (GL1) that decision-makers within organisations may not understand or be interested in risk language or constructs, such as 1% annual exceedance probability (AEP) versus 1-in-100 year average recurrence interval (ARI).

3.2.4 Framing and rationale for projects

A number of projects were not initially conceived as an exercise in risk management. Their main rationale and political driver may have been more focused on factors such as enabling urban and economic regeneration or creating an attractive and functional public realm to improve health and wellbeing of the local population (GM3, NE1). In such cases, little regard may be given to monitoring changes in risk to severe weather events, even if the resultant project is likely to have had benefits in this area.

[10] The GDPR defines 'personal data' as 'any information relating to an individual, whether it relates to his or her private, professional or public life. It can be anything from a name, a home address, a photo, an email address, bank details, posts on social networking websites, medical information or a computer's IP address.

4. Findings – what works for adaptation projects in cities?

This section focuses on the ASC's second research question for this study: What characteristics of successful actions or projects may be transferable to other projects? This is presented as an integrated discussion of factors that, depending on the circumstances of the individual project, could either act to enable or inhibit success (e.g. presence or absence of adequate funding).

Three of the 15 case studies focused on projects relating specifically to partnership working (LO1: London Climate Change Partnership; GL3: Climate Ready Clyde; GM2: Manchester Climate Change Agency). As the aims – and hence what success looks like – are inherently different for these programmes, discussion around their potential enablers and inhibitors of success are presented separately in Section 4.2.

Section 4 – Key findings

- **Adaptation projects should clearly identify where taking action can support delivering multiple benefits**, such as health, regeneration, and quantify these as far as possible. This may increase the chances of a project proceeding, relative to a proposal framed solely around climate change risk. It can be difficult to quantify multiple benefits, although in recent years tools such as CIRIA's Benefits of Sustainable Drainage Systems Tool (BeST) and the Adaptation Support Tool (AST) developed through Imperial College's Blue Green Dream project have made this sort of analysis more accessible to project owners. **Development and mainstreaming of tools** and methodologies should continue to be encouraged and supported through research councils, industry bodies, and government requirements.
- **New funding and governance structures are needed to reduce siloed project design and delivery, encouraging holistic approaches that address climate risk alongside other policy agendas, such as improving health outcomes or place-making**. While holistic approaches may offer strong value for money, under present arrangements they can be challenging to fund, as the costs and benefits fall across different places across the public sector.
- **Providing core funding can help projects focus on delivering against their stated objectives**. The absence of core funding (e.g. to cover ongoing management) has, in some cases, required project owners to undertake an almost continuous process of seeking small grants, thereby reducing their capacity to focus on delivering climate adaptation interventions.
- **Successful adaptation projects establish realistic timescales for development and delivery**. Large scale projects can require significant lead-in times, and innovative approaches naturally take longer to progress. This can be seen negatively by local authorities in particular; ongoing engagement is required to recalibrate the expectations of funders.
- **Government should consider how to de-risk development of funding bids for larger adaptation projects** and reduce barriers to cities accessing such funds. Some of the larger funding sources available for delivering adaptation, such as EU LIFE, involve **high levels of risk and reward**. Cities that are able to be flexible and responsive in bringing the knowledge and skills tailored to bid writing are more likely to attract resourcing.
- **Government should consider how to bridge the gap created from the departure of the EU**. Funding sources such as Horizon2020, EU LIFE and the ERDF played a key role in several projects. While the UK Treasury has outlined that some of these sources are to be underwritten for the current framework programme, there is no clear direction as to whether the UK will continue to be able to access these streams following its departure from the EU, or whether suitable replacements will be provided.

Section 4 – Key findings (continued)

- **Monitoring and evaluation should be central for novel or innovative approaches where effectiveness is not certain**. Where a project's key aim is to demonstrate the value of a particular approach and encourage replication, M&E must be treated as an equally important aspect of the project and early effort should be taken to **establish a strong *ex ante* baseline**. More work is needed to mainstream M&E requirements into funding streams, particularly in relation to where projects deal with climate risks other than flooding.
- **Project owners should map and understand stakeholders at an early stage**. Avoiding technical jargon is important when engaging with the general public.
- **Securing political backing contributes to success**. Projects are more likely to move forward if **high-level** support can be secured from the outset either through backing by elected officials, or through championing the project at an executive level (or both).
- **Cities should consider the use of partnership approaches to create a more enabling environment for adaptation**. While longitudinal studies of the ultimate impacts of partnership programmes such as the LCCP are lacking, there is enough evidence supporting their value for connecting the disparate actors with a role to play in urban climate adaptation, especially given their relatively small resourcing requirements.
- **When engaging with businesses, partnerships need to ensure their work is framed in a tangible and actionable way**. This may include presenting sector-specific business cases that demonstrate the potential for avoided costs and new opportunities. Given the size and variability of the 'business' community, more resourcing of partnerships may be required to tackle this comprehensively.
- While it will not be the right model for all circumstances, **pooling the small discrete budgets of partner organisations can generate more adaptation progress than if these budgets are spent separately**.

4.1 Enablers and barriers to success

4.1.1 Framing and rationale for projects

As noted in Section 3.2.4, many projects with risk reduction benefits are often not framed explicitly in this way. Climate adaptation may not always be top-of-mind for key decision-makers, and hence taking a broad-ranging approach that acknowledges the range of potential project benefits may increase the chances of a project proceeding. It was noted earlier that several projects considered in this study used some form of outcomes-based analysis, such as CBA or SROI (GM1, GM3, GL1, NE2) to account for this broader range of benefits.

Paradoxically, this enabling factor for successful projects was also identified as a challenge for M&E in Section 3.2.4, as broadening the benefits considered makes transparently quantifying the project's outcomes and impacts more difficult, particularly where the benefits relate to subjective factors such as 'sense of belonging'. This being said, in recent years the approaches to quantifying multiple benefits have improved significantly, with a number of the projects highlighting that their work addressed multiple policy agendas, including flooding, heat stress, biodiversity and education (GM1, GM3, GM4, GL2, GL4, NE1, NE2, LO3).

However, while integrated approaches offer strong value for money, they can be challenging to fund, as the costs and benefits fall across different places across the public sector, presenting questions of legitimacy for one partner, policy area or service to take the lead. Instead, it usually results in projects being funded through traditional sources (NE2), with additional benefits being realised regardless of the original intention of the funding source (GM1, GL4, NE2). Therefore an overarching message is that there is scope to improve institutional structures and funding approaches to better encourage and support holistic approaches which address climate risk alongside other policy agendas.

A related enabler is purposefully tying climate resilience with existing investments and linking with existing strategies and policies with political support. The River Roch De-culverting scheme (GM3) has been described as a 'hybrid scheme' where heritage conservation and urban regeneration were the main drivers. Addressing flood risk management was an additional but critical factor in securing support and funding for the scheme (e.g. from the EA) and in making heritage conservation and urban regeneration actually possible by reducing flood risk to properties and improving the resilience of the town centre.

Similarly, in the Science Central project (NE1), Newcastle City Council (NCC) wanted to develop the large but derelict former Newcastle Brewery site in the city centre. In partnership with Newcastle University, NCC assessed what the city needed in terms of infrastructure. The aim was to promote science-led innovation in a wide spectrum of disciplines (e.g. digital, life-sciences). However, the university also championed the research of SDS by interlinking the SDS infrastructure with the public space, developing a 'functional landscape' of visible water retention as a solution for flood risk management.

4.1.2 Funding and resources

A lack of funding and resources were common themes identified as barriers within adaptation projects. Staff leaving organisations or changing roles leads to a lack of continuity in project delivery and a loss of knowledge and institutional understanding.

In the Seven Lochs Wetland Park and Green Network Strategy (GL2) project, an opportunity to better integrate the park into the planned development around the park was reportedly missed as there were insufficient resources in place to carry out early engagement with the local planning authority. However, in this project, having a dedicated Project Officer put in place through engagement with a partner organisation was shown to be beneficial in other ways, through having someone wholly dedicated to undertaking the necessary up-front evidence gathering and stakeholder engagement activities.

Having unrealistic expectations about project implementation timescales can also act as a barrier to success. Large scale projects can require significant lead-in times, and this can be seen negatively by local authorities in particular. In the example of project GL2, the local authority was seen as being relatively risk averse and so establishing buy-in and commitment to form the necessary partnerships and relationships proved to be time-consuming and complex, and this type of risk appetite can be discouraging to change. The eventual formation of a partnership with the Glasgow and Clyde Valley Green Network Partnership allowed for the project to be more effectively progressed and for access to different types of funding and support (including a dedicated Project Officer) to be facilitated.

A lack of core funding has been identified within the research as a potential barrier to success. For example, the 'A Certain Future' project in Manchester (GM2) faced a challenge linked to its funding mechanisms, where it is argued that, in the absence of core funding, it spent a disproportionately large amount of time seeking funding through highly competitive project-specific grants, thereby constraining MCCA's ability to reach its capacity and fully achieve its purpose. This was similar for other project such as Lost Effra (LO4), an innovative SDS scheme in South

London that has been in an almost continuous process of seeking small grants to keep the project going. This funding insecurity has jeopardised the project's ability to scale up at as rapidly as was hoped.

Some of the larger funding sources available for delivering adaptation are risky and competitive for cities to access. Discussions with Manchester Climate Change Agency on Grow Green (GM4) highlighted the high levels of risk and reward, with their application for EU Horizon 2020 funding taking significant effort, but of the initial 32 applications, only four were finally funded – a 13% chance. In these instances, both the relatively short deadlines and resources are issues, and cities that are able to be flexible and responsive in bringing with the knowledge and skills tailored to bid writing are more likely to be attract resourcing. Some organisations already use bid-writing consultants to increase their chances.

It was also reported that stipulations accompanying an offer of funding (such as the timeframes in which funding needs to be spent) can inhibit success. Therefore, a more consistent, reliable set of project development funding, which helps smooth out this nature could further help cities in developing pipelines of adaptation projects.

Despite the challenges associated with EU funding, Figure 6 shows how important these funds can be for catalysing action – 8 of the 36 funding sources reported for short-listed projects are EU-based (GM4, NE1, NE5).

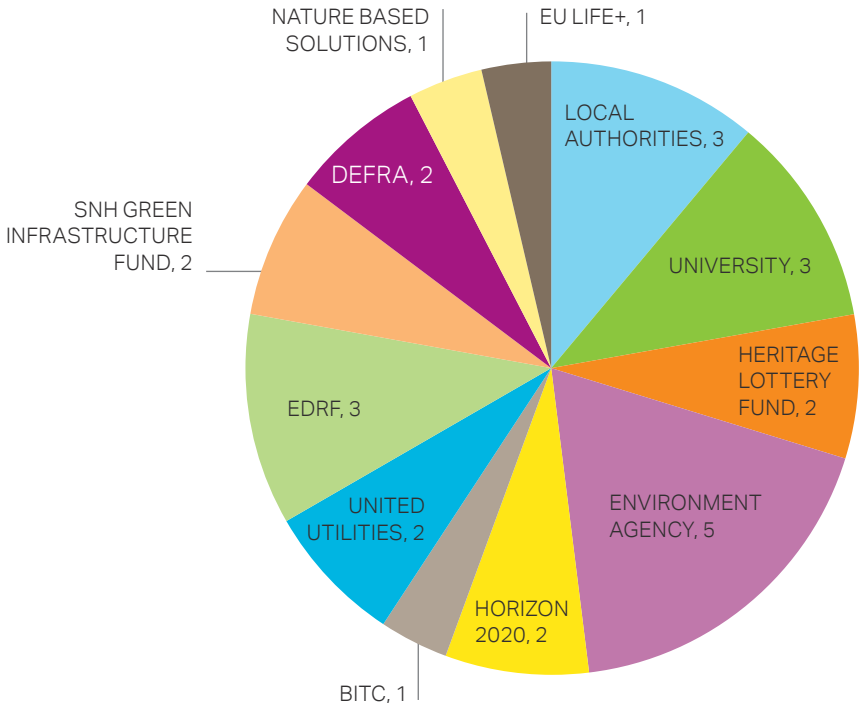


Figure 6 Reported funding sources for short-listed case studies

While the UK Treasury has outlined that EU sources are to be underwritten for the current framework programme, and the UK Government's white paper outlines it wishes to continue participation in Horizon 2020, there is currently little clarity as to whether the UK will continue to be able to access these streams following its departure from the EU, or whether suitable replacements will be provided by UK and devolved governments. As it stands, this uncertainty presents an emerging barrier to cities' adaptation action. Whilst other funding streams exist for flood risk management, these will inevitably become more competitive, and it is not clear how cities will finance action on other hazards.

Securing and retaining funding for maintenance activities is another identified challenge. In the Sighthill/North Glasgow Integrated Water Management System (NGIWMS) project (GL4), regulatory cycles in the water sector, and the complexity around which organisation(s) should manage the project risks, meant that ownership of the maintenance activities and its funding was not taken on board by any single organisation. This type of situation can lead to the establishment of a complex funding model, which, unless clearly documented and formalised, can inhibit maintenance activities.

Finally, in England the whole-of-life costs of operating a SDS scheme can be a problem, as the lack of clear liabilities or responsibilities, combined with funding pressures on public organisations can result in organisations seeing SUDS as a future cost or liability. This is also linked to wider governance, since there is no consistent approach to allocating the long term responsibilities for SDS maintenance and adoption across England and Wales. In contrast, under the Water Environment (Controlled Activities) (Scotland) Regulations 2011, new developments with surface water drainage systems discharging to the water environment are generally required to pass through SUDS, with SEPA seeking a guarantee for the long term maintenance and sustainability of any SDS implemented.

Practical innovation can also help overcome some of these challenges. For example, the Crown Woods Way (LO2) project has actively sought to use off-the-shelf components for its SDS scheme, thereby reducing the need for bespoke maintenance regimes or use of custom materials should repairs be required.

4.1.3 Monitoring, evaluating and communicating outcomes

For projects seeking to demonstrate and convince others of the merits of a particular approach, monitoring and evaluation is a key success factor and should be treated as a core project activity, rather than an afterthought. While a strong approach to evaluating impact was lacking from some project, Climate-proofing Social Housing Landscapes (LO3) was a clear exemplar in this area, dedicating more than 10% of its total project budget to a range of monitoring and evaluation activities. Being able to demonstrate impact has reportedly led to some success in terms of replication, with the project proponent Groundwork receiving additional funding to implement SDS measures in other parts of London.

Similarly, a key output of the Leicester SDS Programme (LE3) has been good practice guidance in the form of a Sustainable Drainage Guide in 2015, which contains guidance and examples of SDS techniques and schemes, and is aimed primarily at developers. Through this, Leicester City Council is able to share lessons learnt and best practice in regards to sustainable drainage with other local authorities and developers around the UK. In addition to the Sustainable Drainage Guide, Leicester City Council facilitates regular SDS stakeholder group meetings to share knowledge and information on new developments and techniques, as well as to provide training on the use of SDS.

4.1.4 Stakeholder involvement and relationships

Several interviewees stressed how important it was to undertake early and comprehensive stakeholder analysis and to establish an honest dialogue with a broad range of stakeholders and the public in general (NE1, NE2, GM3, GM2, GL1, LE2, LO2, LO3, LO4), An early and thoughtfully planned communication plan or a 'social marketing' strategy has been seen as a success factor to 'tell a story well' in an accessible language, tailored to the specific audience. Avoiding technical jargon has also been attributed to getting stakeholders on board early and therefore avoiding opposition and possible delays.

This study has also come across some interesting and innovative approaches to overcoming reluctance to participate by key stakeholders. At Brunton Park (NE3), the use of a golf course designer to demonstrate how a flood scheme could also improve the quality of the course, as well as delivering flood reduction was a key factor in unlocking the buy in of an adjacent golf course. Similarly, White Cart (GL1) employed the use of an agricultural specialist to engage some landowners.

It was also reported that in situations where cities are seeking to facilitate change and improvement following on from severe weather events, having transparent, open and early communication with citizens is crucial. The Newcastle Scrutiny Review process following the 2012 flooding (NE3) included roadshows and exhibitions, putting citizens at the heart of the process and enabling the Council to learn lessons related to response, recovery and longer term planning. This was important for giving the organisation space to respond to these changes in future, as well as establishing important feedback loops to improve the City's adaptive capacity.

Private sector involvement was also a key factor in successes for projects such as GM1; here it was suggested that private sector organisation can sometimes be more willing to try innovative approaches. However, while this can be successful, it can also mean it creates challenges when working with or engaging organisations that are used to more established approaches.

4.1.5 Policy, legislation and enabling environment

Across the range of projects, it was apparent that strong central political support and enabling environments played a significant role in driving adaptation action. The current English legislation on cities for adaptation is limited, requiring consideration only in planning, public health and flood risk management, despite climate change having impacts across the range of functions. However, Glasgow, Newcastle and Leicester have voluntarily signed up to Mayors Adapt, or the Covenant of Mayors on Climate and Energy, committing to report progress on adaptation every two years across the breadth of activity in their cities.

In contrast to English legislation, section 44 of the Climate Change (Scotland) Act 2009 requires all public bodies (including Local Authorities), in exercising their functions, to act in a way best calculated to help deliver the Scottish Climate Change Adaptation programme (SCCAP). It also requires all 180 public bodies to report their progress on adaptation on an annual basis. The UK could also benefit from strengthening or encouraging requirements or guidance for cities on how to address future climate risk into project design. At present, EA and SEPA funding approaches to flood risk management have requirements for accounting for climate change, but these do not deal with the wider range of hazards such as urban heat, landslides and storms.

However, there is emerging evidence of EU methods being adopted in the UK, based on the EU Non-paper Guidelines for Project Managers: Making vulnerable investments climate resilient.[11] These were used to conduct climate risk and vulnerability assessments in partnership with the private sector for both Science Central & East Pilgrim St (NE1, NE5), as part of EIB Technical Assistance funding, but we also found wider uptake in Glasgow City Region through Climate Ready Clyde (GL3). Such approaches are also being encouraged as part of the application process for the European Regional Development Fund, but are not clearly emphasised in current guidance. As noted earlier, the ability of existing tools such as CIRIA BeST to provide an 'off-the-shelf' approach was also common amongst a number of projects, including GM1, NE1 and LO3. The forthcoming ISO14091 standard on climate vulnerability assessment will continue to strengthen approaches in this area.

Being able to specify established tools and methodologies makes it easier for cities when designing and commissioning projects. They can act as shorthand to specify leading edge risk reduction methodologies or appraisals that can be incorporated into procurement guidance or replicated and transferred to other projects. Therefore, the development and mainstreaming of tools and methodologies should continue to be encouraged and supported through research councils, industry bodies, and government requirements.

[11] https://climate-adapt.eea.europa.eu/metadata/guidances/nonpaper-guidelines-for-project-managers-making-vulnerable-investments-climate-resilient/guidelinesfor-project-managers.pdf

4.1.6 Project governance and high level support

In a number of projects, participants stressed the importance of securing high-level support from the outset of a project proposal, either through a show of political will and backing by elected officials, or through championing the project at an executive level. Internal support needs to be quickly followed by support among a broader cohort of stakeholder organisations by setting up a project management or steering group (GM3, NE1, NE2, NE5, GM2, LO3). In GM3 a steering group (comprising the EA, Historic England, United Utilities and Rochdale Borough Council) was set up as a high-level executive board to champion a proposal by making strategic decisions, thereby enabling a project delivery/coordination group to manage the more technical construction aspects of the scheme with the necessary backing and support.

Since most of the projects involved some sort of construction and ground works, participants on those projects also highlighted that it proved essential to involve the relevant local and regional utility companies from the outset of the project (GM5, GM3, GL1, NE2, NE5, LO3, LO4). This was more than simply a risk and relationship management exercise for projects such as Climate Proofing Social Housing Landscapes (LO3) – Thames Water were an active partner, as it understood the potential for a direct commercial benefit by promoting approaches that minimise the amount of water entering London's overstretched drainage systems.

4.2 Findings for regional partnerships

This section provides additional findings related to the regional partnership projects considered in this study; specifically LCCP, Climate Ready Clyde (CRC) and Manchester Climate Change Agency (MCCA). These are discussed separately due to inherent differences with many of the other projects considered, in that the partnerships largely aim to facilitate action among a range of other actors, as opposed to implementing a specific physical intervention or interventions.

Overall, it has proven difficult to draw firm conclusions each partnership's level of impact. This is not to discount the value of partnership working models, as there is significant evidence in the literature supporting their value for connecting the disparate actors with a role to play in urban climate adaptation.[12] However, when the assessment approach used in this project was applied to the partnership programmes, there is typically little quantitative evidence that can establish causal links between outputs and their resultant impact.

4.2.1 Governance and operating models

The three partnerships considered all have distinctly different operating models and funding structures, as summarised in Table 2.

[12] See Climate Just (undated) Benefits of working in partnership, http://www.climatejust.org.uk/messages/benefits-working-partnership [Accessed 3 June 2018].

Table 2 Comparison of partnership projects

	LONDON climate change PARTNERSHIP	ClimateReadyClyde	MANCHESTER CLIMATE CHANGE AGENCY
Background	Initially established 2002, LCCP was one of several regional partnerships established in the early 2000s. Based within the GLA, it is a forum for knowledge exchange between the scientific community, policy makers, and practitioners working in London.	The programme concept was initiated by Adaptation Scotland in 2012 as an acknowledgement that adaptation should be place-based. It started with a vision for a resilient Clyde, which was endorsed by a number of local partners, eventually leading to the common model which supports a 1.45 FTE secretariat.	In 2009, Manchester City Council (MCC) published 'Manchester: A Certain Future', which highlighted that climate change issues are too big to be addressed by the Council alone. It was decided that a city-wide, independent and transparent organisation was needed to facilitate climate change across the City and not just for the MCC.
Governance structure	Core Steering Group comprising 'members' spanning the academic, public, private and third sectors. Members must actively agree to Terms of Reference but are not required to pay any subscription fee. The intent is for members to collectively decide on the direction and activities of the partnership. Those involved from time to time in the LCCP's activities are termed 'partners'.	Membership-based model. Board comprising University of Strathclyde, Scottish EPA, Transport Scotland, Strathclyde Partnership for Transport, Scotia Gas Networks, NHS Greater Glasgow and Clyde, University of Glasgow and the and six of the region's eight unitary authorities.	The Manchester Climate Change Board includes experts from the UoM and senior representatives from other sectors in the city. The experts are able to support and advise other sectors on climate change issues. A new multi-sectoral governance structure is being developed and will be implemented in 2018.
Funding	GLA funding for the Partnership Manager who runs the Secretariat function.	Scottish Government provided core funding of £100,000 for start-up of the partnership. In 2017, a pooled funding model was implemented – 13 partner organisations contribute approximately £7,250 per year.	MCC, private sector sponsors and funded projects (e.g. European Commission).
Actions/ activities	– Regularly convening meetings and stakeholder events. – Providing ad-hoc advice and support to partner organisations. – Sharing information with members and partners about expected climate change, its impacts on London and examples of suitable adaptation actions – Delivering specific projects and commissioning research, where appropriate. – Currently developing a framework for monitoring adaptation progress in London.	– Producing a Regional Adaptation Strategy and Action Plan, supported by a Climate Risk and Opportunity Assessment. – Operating a secretariat function that provides some direct technical support to members. – Attending national and international events as a representative of the city region. – Seeking to identify and obtain funding sources for adaptation work in the region. – Facilitating adaptation-related student placement schemes for partner organisations. – Using the city as a test-bed for research programmes.	– Facilitating public consultations and policy making. – Establishing new partnerships. – Seek funding for adaptation projects. – Promote and report on progress to address climate change.
Examples of reported outcomes	– New connections facilitated between members and partners, leading to projects that may otherwise not have happened. – Increased capacity of partners and members to act as 'champions' for adaptation within their own organisations.	– Influence over future development projects underway in the region. – Contributed to Glasgow's selection in the 100 Resilient Cities network. – Aggregating discrete small funding from members a more efficient use of resources.	– Generated £5m for new projects, including Grow Green, a Horizon 2020 project delivering green infrastructure on the ground. – Ongoing cross-sector senior governance of climate change in Manchester.

Each partnership's operating model is a response to the local context and enabling environment, and hence it is not possible to draw conclusions around which approach is most effective. However, some observations can be drawn across the three partnerships:

- Given many participants contribute to partnerships on a voluntary basis, or at least in addition to their existing responsibilities, making efficient use of time is crucial for ongoing engagement. This requires partnership managers to communicate clearly and concisely, making sure those involved feel they have benefited from participating. This applied to all models, although the need for participants to benefit from the relationship is perhaps more explicit in the CRC model since members contribute financially.
- As noted in Section 4.1.2, availability of core funding can be a key enabler of success. All three partnerships have this in place now, although each through a different approach. The former absence of core funding for MCCA was seen as a major distraction from undertaking its core functions, as a significant amount of time was spent seeking project-based grant funding. This lack of certainty about the future of a partnership can also adversely affect willingness of partners to participate.
- Engagement with businesses was regularly reported as challenging area for partnerships. For example, the LCCP Steering Group includes a representative from London First, which is a business campaigning group; however, Lloyds is the only private sector organisation among its listed partners. However, the point was also made that 'business' is a somewhat unhelpful category around which to plan engagement, given the extremely diverse range of organisations (e.g. multinationals versus SMEs) and activities it represents. Making engagement with businesses more effective will be resource-intensive, as the appropriate 'pitch' will vary depending on the drivers of different sectors. More can be done to present the opportunities for businesses presented by adaptation (e.g. avoided cost) in sector-specific business cases.
- Despite their importance for as a cross-sectoral convening mechanism, staff resourcing for the secretariat function of partnerships is low (1-2 full-time equivalent (FTE)). This increases the importance of having the right staff in place, supported by a well-connected and consultative chair, as well as member organisations that are prepared to make an active contribution.

4.2.2 Growing the evidence base and case for action

Flooding is the by far the most commonly-targeted hazard among the long list of 58 projects, and indeed the short-list of 25. This occurred despite the project actively seeking to projects covering a wide variety of hazards. On the one hand, this reflects that flooding and coastal change is one of the six most urgent groups of risks in the UK CCRA, and that approaches to management of the risks have been in place for a significant period of time.

However, 'risks to health, well-being and productivity from high temperatures' are given the same weighting in the UKCCRA, and the UK is already experiencing impacts of other hazards, (e.g. landslides in Scotland, overheating in care homes[14]) yet far fewer projects appear to be underway in this area. A key factor in this disparity is the stronger
and more well-established legislative drivers for flood risk management, which may in driven by cognitive bias toward more readily observable nature of events such as floods. Flooding may also have a lasting impact after the event, whereas the most of the impacts associated with extreme heat tend to dissipate quickly with a change in weather.

The partnerships reviewed in this study play a key role in addressing this bias by working to strengthen the evidence base around the effects of climate change and the need for action in their respective cities. For example, CRC (GL3) is currently producing 'Glasgow City Region's Climate Change Risk and Opportunity Assessment', which will be followed by a 'City Region Climate Change Adaptation Strategy and Action Plan'. Linking the research and practitioner communities is also a key aim of the LCCP (LO1) – it has not sought to do this by producing a specific risk assessment, but rather through targeted publications and ongoing engagement between members and partners.

Establishing an evidence base around climate risk and the need for adaptation has helped the partnerships to establish their legitimacy. It was reported that CRC found it far more effective to make the case to potential partners in an evidence-based manner, rather than presenting climate change as a moral imperative.

CRC established a prospectus[14] for the partnership around the economic imperative for adaptation, including reference to issues around value-for-money, efficiency and climate justice (which has been a key policy area for the Scottish Government). The prospectus was pitched at Chief Executive level personnel and included a covering letter from the relevant Scottish Government cabinet secretary. This approach has been credited with helping to attract partners.

For the LCCP, its legitimacy has been acknowledged in the Mayor of London's new Environment Strategy (released May 2018), which tasks the Partnership with monitoring and evaluating London's adaptation progress. It is currently working with partners to develop a framework for that is applicable across different sectors.

[13] Joseph Rowntree Foundation (2016) Care provision fit for a future climate, https://www.jrf.org.uk/file/49106/download?token=bp-sRo2s&filetype=findings.

[14] https://www.sniffer.org.uk/Handlers/Download.ashx?IDMF=1e9f7fe3-1bd5-4616-84e8-d73b87cc0e98.

Appendix A
Literature review of existing adaptation monitoring and evaluation approaches

A review of publicly available literature was conducted to explore the different approaches to monitoring and evaluating climate change adaptation actions. This involved a comprehensive search of online resources from the UK and internationally, including publications, articles, reviews, websites, guides, reports and tools. Combinations of the following key search words were used:
- Climate Change Adaptation; Disaster Risk Reduction; Resilience.
- Monitoring; Evaluation; M&E; Measuring; Measurement.
- Framework; Guide; Approach; Tool; Toolkit; Manual; Methodology.

All literature sources that met the search criteria were subject to in-depth review. In total, 23 tools, frameworks and guides were reviewed, as summarised in Table A.1 below. For each framework, details such as geographical scale (e.g. international, focus area (e.g. coastal management), M&E approach, and indicator types were recorded. The information was then analysed to understand commonalities in approach across the frameworks. While there was variation in terminology and approaches, it was possible to identify a series of over-arching steps that were common to many of the frameworks. This is illustrated in Table A.2.

Table A.1. Overview of monitoring and evaluation frameworks for assessing climate change adaptations.

Approach / Framework	Organisation	Overview	Focus area & scale	Approach	Indicators	Reference
Monitoring and evaluation framework for adaptation to climate change	United Nations Development Programme (UNDP)	Guide for UNDP staff to design monitoring and evaluation frameworks for Climate change adaptation initiatives, including a review of multi-level approaches.	Focus on National Adaptation Programmes of Action (NAPAs), so not readily adaptable. Focus areas: – Agriculture/food security – Water resources and quality – Public health – Disaster risk management (DRM) – Coastal zone development – Natural resource management – Infrastructure Applicable scales: – International – National	N/A	Standard indicators (applicable across all areas) and supplementary indicators (defined for each area) Indicator Types: – Coverage – Impact – Sustainability – Replicability	http://www.un.org/esa/sustdev/natlinfo/indicators/15Oct_2008/presentations_pdf/Bo%20Lim.pdf
Evaluation of adaptation to climate change from a development perspective	Institute of Development Studies (IDS)	Literature review to identify issues and approaches for evaluation of adaptation measures	Applicable scales: – International – National – Sectoral – Project – Household	N/A	Indicator Types: – Process – Outcomes – Behaviour – Welfare	https://www.ids.ac.uk/go/idsproject/evaluating-adaptation-to-climate-change-from-a-development-perspective
Tracking progress for effective action	Global Environment Facility Evaluation Office (GEF-EO)	Overview, review and recommendations for monitoring and evaluation climate change adaptations	Focus area: Disaster risk management Applicable Scale: National	N/A	N/A	https://www.climate-eval.org/sites/default/files/studies/Climate-Eval%20Framework%20for%20Monitoring%20and%20Evaluation%20of%20Adaptation%20to%20Climate%20Change.pdf
Learning to ADAPT	Strengthening Climate Resilience (SCR)	Reviews current adaptation evaluation efforts and provides guidance on how to evaluate and monitor adaptation better. The following ADAPT principles are identified: – Adaptive – Dynamic – Active – Participatory – Thorough	Applicable Scale: – National	N/A	N/A	https://www.ids.ac.uk/files/dmfile/SilvaVillanueva_2012_Learning-to-ADAPTDP92.pdf

Approach / Framework	Organisation	Overview	Focus area & scale	Approach	Indicators	Reference
Monitoring and Evaluation for Adaptation	Organisation for Economic Co-Operation and Development (OECD)	Assessment of measurement and evaluation frameworks used for adaptation projects	Applicable Scale: – International – National – Sub-national	N/A	Indicator types: – Quantitative – Qualitative – Binary	http://www.oecd-ilibrary.org/environment/national-adaptation-planning_5k483jpfpsq1-en
AdaptME Toolkit	United Kingdom Climate Impacts Programme (UKCIP)	Guide to designing monitoring and evaluation frameworks for adaptation projects.	Flexibility to be applied to any context	Question-based approach with the following steps: 1. The purpose of the evaluation 2. The subject being evaluated 3. Logic and assumptions underpin the intervention 4. Challenges and limitations of the evaluation 5. Measuring progress and performance 6. Establishing an evaluation criteria (indicators) 7. Engaging people in the evaluation and communicating the findings	N/A	http://www.ukcip.org.uk/wp-content/PDFs/UKCIP-AdaptME.pdf
Climate change adaptation monitoring and assessment tool (AMAT)	Global Environmental Facility (GEF)	Tool to measure outputs and outcomes from the Special Climate Change Fund (SCCF) and the Least Developed Countries Fund (LDCF).	Specific to SCCF and LDCF projects, so not readily adaptable. Applicable scales: – International – National	Top down approach with the following steps: 1. Pre-determined objectives and outcomes 2. Pre-determined indicators 3. Measurement and assessment 4. Reporting is required at approval, mid-tem and competition.	Pre-defined indicator for each outcome	https://www.thegef.org/documents/gef-climate-change-adaptation-tracking-tool
Participatory monitoring, evaluation, reflection and learning (PMERL) project for community-based adaptation	CARE	Step by Step guide for monitoring and evaluating community based climate change adaptation.	Applicable scale: – Field level	MERL approach (Monitor, Evaluate, Reflect on and Learn), with the following steps: 1. Mapping key stakeholders and strategic interests 2. Decide what to monitor 3. Develop indicators 4. Measure baselines and assemble information 5. Put monitoring plan together and match with available resources	Indicator types: – Quantitative – Qualitative	https://careclimatechange.org/tool-kits/pmerl/
Climate Resilience Framework (CRF) training manuals	Institute Social and Environmental Transition (ISET)	Framework and tools for climate change resilience in urban settings.	Focus Area: – Urban Applicable scale: – Sub-national	N/A	Bottom-up development of specific indicators	http://training.i-s-e-t.org/

Approach / Framework	Organisation	Overview	Focus area & scale	Approach	Indicators	Reference
Making adaptation count	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (BMZ), and World Resources Institute (WRI)	Guide to development a monitoring and evaluation framework for a specific climate change adaptation.	Flexibility to be applied to any context	Design process with the following steps: 1. Describe the adaptation context 2. Identify contribution to adaptation 3. Form an adaptation hypothesis 4. Create an adaptation theory of change 5. Choose indicators and set a baseline 6. Use the Monitoring and Evaluation system	Indicator types: – Process – Outcome	http://pdf.wri.org/making_adaptation_count.pdf
Adaptation made to measure	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (BMZ)	Step-by-step guide to designing a monitoring framework for an adaptation project.	Applicable scale: – Project level	Design process with the following steps: 1. Assess context for adaptation 2. Identify the contribution to adaptation 3. Develop results framework 4. Define indicators and set a baseline 5. Operationalise results-based monitoring system	SMART indicators	http://www.adaptationcommunity.net/?wpfb_dl=52
Monitoring & Evaluation for community-based adaptation	Action Research for Community Adaptation in Bangladesh (ARCAB)	Monitoring and evaluation framework applied to a community based adaptation case study.	Focus Area: – Vulnerable people Applicable scale: – Community	Bottom-up, theory based approach with the following steps: 1. Map out a theory of change 2. Develop indicators and data collection tools 3. Collect baseline and track changes 4. Review baseline with changing contexts and new knowledge	N/A	http://webapp-hq.nl/sites/default/files/documents/2012%2011%20ARCAB%20MandE%20for%20CBA%20Final%20Report.pdf
Adaptation M&E discussion papers	United Nations Framework on Climate Change (UNFCC)	Review of existing monitoring and evaluation approaches.	Applicable scale: – International – National	Adaptation policy process with the following steps: 1. Assessment of adaptation needs 2. Objectives of adaptation measures 3. Inputs (human, financial and technological resources) 4. Outputs (adaptation interventions) 5. Outcome (immediate effect on target groups and systems) 6. Impacts (ultimate effect on groups and systems) 7. Indicators	N/A	https://unfccc.int/resource/docs/2010/sbsta/eng/05.pdf https://unfccc.int/event/adaptation-committee-workshop-on-the-monitoring-and-evaluation-of-adaptation
Tracking adaptation and measuring development (TAMD)	International Institute for Environment and Development (IIED)	Tool and guide for adaptation monitoring of climate change management interventions (track1) and development and adaptation outcomes (track 2).	Flexibility to be applied to any context	Twin-track approach with the following steps: 1. Define the evaluation context and purpose 2. Establish a theory of change 3. Identify relevant scales 4. Locate outputs, outcomes and impacts on TAMD framework 5. Identify indicator types 6. Define indicators 7. Gather data 8. Analyse indicators and data at different levels of track 1 & 2 9. Address attribution	Indicators categorised into scale and track type	http://pubs.iied.org/10038IIED/

Approach / Framework	Organisation	Overview	Focus area & scale	Approach	Indicators	Reference
Community-based resilience assessment (CoBRA) conceptual framework and methodology	United Nations Development Programme (UNDP)	Conceptual framework for measuring the impacts of risk reduction programs.	Focus area: – Disaster risk reduction – Drought risk reduction Applicable scale: – Vulnerable communities – Vulnerable households	Process orientated, bottom-up approach with the following steps: 1. Identify target area 2. Prepare for fieldwork 3. Identify and train field staff 4. Data collection 5. Data analysis 6. Preparing and using finding 7. Repeat monitoring of impact and change	N/A	http://www.undp.org/content/undp/en/home/librarypage/environment-energy/sustainable_land_management/CoBRA.html
Pilot Program for Climate Resilience (PPCR) monitoring and reporting toolkit	Climate Investment Funds (CIF)	Instruction for governments implementing climate resilience programs under CIF's PPCR, to ensure consistent collection and reporting of data.	Specific to PPCR projects, so not readily adaptable. Applicable scale: – National	Scorecards with pre-determined indicators to record measurement and assessment.	5 core indicators: – Climate change integration into national planning – Strengthening of governance capacity to mainstream climate resilience – Extent vulnerable households, communities, businesses and services use tools to respond to climate change – Number of people supported to cope with climate change	https://www.climateinvestmentfunds.org/knowledge-documents/ppcr-monitoring-and-reporting-toolkit
Saved health, saved wealth: An approach to quantifying the benefits of climate change adaptation	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ)	Methodology and tool to quantify the benefits of climate change adaptation measures.	Focus area: – Coastal zone management – Flood prevention and mitigation Applicable scale: – Sub-national	Cost-benefit analysis, with the following steps: 1. Define the applicability and boundaries of the methodology 2. Derive baseline scenario 3. Describe project scenarios 4. Assess saved wealth, saved health and environmental benefits/impacts 5. Define monitoring parameters	Indicator types: – Saved health – Saved wealth	https://gc21.giz.de/ibt/var/app/wp342deP/1443/wp-content/uploads/filebase/me/me-guides-manuals-reports/giz_2013_Saved_health_saved_wealth_-_an_approach_to_quantifying_the_benefits_of_climate_change_adaptation.pdf
Programme of research on vulnerability, impacts, and adaptation (PROVIA)	United Nations Environment Programme (UNEP)	International guidance for assessing climate change vulnerability, impacts and adaptation.	Flexibility to be applied to any context	N/A	N/A	https://www.sei-international.org/mediamanager/documents/Publications/Climate/PROVIA-guidance-Nov2013-summary-low-res.pdf
Monitoring and evaluating adaptation at aggregated levels: A comparative analysis of ten systems	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (BMZ)	Literature review of monitoring and evaluation practices of adaptation across all scales.	Applicable scales: – Global – Regional – National	N/A	N/A	https://gc21.giz.de/ibt/var/app/wp342deP/1443/wp-content/uploads/filebase/me/me-guides-manuals-reports/GIZ_2014-Comparative_analysis_of_national_adaptation_M&E.pdf

Approach / Framework	Organisation	Overview	Focus area & scale	Approach	Indicators	Reference
Results framework and baseline guidance: Project level	Adaption Fund (AF)	Step by step instructions on designing evaluation frameworks in line with the Adaption Fund requirements.	Specific to Adaption Fund principles, so not readily adaptable. Applicable scales: – National – Sub national	Results-based framework with the following steps: 1. Define intended effect and scale of intervention 2. Analyse and formulate project objectives and analyse alternatives 3. Align project objectives with Adaption Fund strategic outcomes 4. Include project indicators and select core adaptation fund indicators 5. Set targets 6. Monitor data 7. Review and report data	Specific core Adaption Fund indicators	https://www.adaptation-fund.org/document/results-framework-and-baseline-guidance-project-level/
Framework for Resilient Development in the Pacific (FRDP)	Developed by Steering Committee members (SPREP, SPC, PIPSO and others)	Guide to strengthening climate change resilience, with reference to two previous regional frameworks for Pacific Island countries.	Specific to the Pacific islands, so not readily adaptable. Applicable scales: – National – Sub national	N/A	N/A	http://gsd.spc.int/frdp/assets/FRDP_2016_Resilient_Dev_pacific.pdf
Urban Climate Action Impacts Framework (UCAIF)	C40 Cities Climate Leadership Group	User guide for assessing urban climate change actions.	Focus Area: – Urban Applicable scale: – Sub-national	Cost-benefit analysis, impact assessment and Intervention logic, with the following steps: 1. Actions 2. Outputs 3. Outcomes 4. Impacts 5. Indicators	Indicator types: – Social – Economic – Environmental	https://c40-production- images.s3.amazonaws.com/other_uploads/images/1605_C40_UCAIF_report_V3.original.pdf?1518203136
Adaptation Workbook	Northern Institute of Applied Climate Science (NIAPC)	Workbook for designing climate change management actions.	Focus areas: – Forestry – Agriculture Applicable scale: – Sub-national	N/A	N/A	https://adaptationworkbook.org/

While there was variation in the terminology and approaches used across the different frameworks, it was possible to identify a series of overarching steps that were relatively common across the frameworks. It is important to acknowledge that these steps represent an ideal scenario (e.g. project is clearly defined; a clear baseline was established; monitoring has been undertaken):

1. Identify which element of risk the project is seeking to address, i.e. 'exposure' and/or 'vulnerability' (comprising 'sensitivity' and 'adaptive capacity').
2. Map out the 'theory of change'. In other words, what is the thinking behind how taking a given action will have an impact on the level of risk?
3. Determine indicators to demonstrate the actions, project's outputs, outcomes and impacts
4. Where the data is available, measure change between the baseline (*ex ante* – before the project) and *ex post* (after the project).

Table A.2 breaks down the different monitoring and evaluation approaches into their individual steps and identifies which of the overarching steps (listed above) these correspond to. While some of the frameworks have additional steps and others are missing some of the overarching steps, this unifying framework represents an effective approach for monitoring and evaluating climate change adaptation projects.

Table A2. A breakdown of the steps taken by different monitoring and evaluation frameworks, and their correspondence with the overarching steps from a unifying and overarching approach.

Framework	Approach steps	Overarching steps
AdaptME toolkit	1. The purpose of the evaluation	1
	2. The subject being evaluated	1
	3. Logic and assumptions underpin the intervention	2
	4. Challenges and limitations of the evaluation	-
	5. Measuring progress and performance	3
	6. Establishing an evaluation criteria (indicators)	4
	7. Engaging people in the evaluation and communicating the findings	-
Climate change adaptation monitoring and assessment tool (AMAT)	1. Pre-determined objectives and outcomes	1/2
	2. Pre-determined indicators	3
	3. Measurement and assessment	4
Participatory monitoring, evaluation, reflection and learning (PMERL) project for community-based adaptation	1. Mapping key stakeholders and strategic interests	-
	2. Decide what to monitor	1
	3. Develop indicators	3
	4. Measure baselines and assemble information	4
	5. Put monitoring plan together and match with available resources	-
Making adaptation count	1. Describe the adaptation context	1
	2. Identify contribution to adaptation	1
	3. Form an adaptation hypothesis	1
	4. Create an adaptation theory of change	2
	5. Choose indicators and set a baseline	3
	6. Use the Monitoring and Evaluation system	4
Adaptation made to measure	1. Assess context for adaptation	1
	2. Identify the contribution to adaptation	1
	3. Develop results framework	2
	4. Define indicators and set a baseline	3
	5. Operationalise results-based monitoring system	4
Monitoring & Evaluation for community-based adaptation	1. Map out a theory of change	2
	2. Develop indicators and data collection tools	3
	3. Collect baseline and track changes	4
	4. Review baseline with changing contexts and new knowledge	4
Adaptation M&E discussion papers	1. Assessment of adaptation needs	1
	2. Objectives of adaptation measures	1/2
	3. Inputs (human, financial and technological resources)	1/2
	4. Outputs (adaptation interventions)	1/2
	5. Outcome (immediate effect on target groups and systems)	1/2
	6. Impacts (ultimate effect on groups and systems)	1/2

Framework	Approach steps	Overarching steps
Tracking adaptation and measuring development (TAMD)	1. Define the evaluation context and purpose	1
	2. Establish a theory of change	2
	3. Identify relevant scales	-
	4. Locate outputs, outcomes and impacts on TAMD framework	2
	5. Identify indicator types	3
	6. Define indicators	3
	7. Gather data	4
	8. Analyse indicators and data at different levels of track 1 and track 2	4
	9. Address attribution	4
Community-based resilience assessment (CoBRA) conceptual framework and methodology	1. Identify target area	1
	2. Prepare for fieldwork	-
	3. Identify and train field staff	-
	4. Data collection	4
	5. Data analysis	4
	6. Presenting and using findings	-
	7. Repeat monitoring of impact and change	4
Pilot Program for Climate Resilience (PPCR) monitoring and reporting toolkit	1. Five core pre-determined indicators	2
	2. Measurement and assessment	4
Saved health, saved wealth: an approach to quantifying the benefits of climate change adaptation	1. Define the applicability and boundaries of the methodology	-
	2. Derive baseline scenario	4
	3. Describe project scenarios	1/2
	4. Assess saved wealth, saved health and environmental benefits/impacts	4
	5. Define monitoring parameters	3
Results framework and baseline guidance: Project level	1. Define intended effect and scale of intervention	1
	2. Analyse and formulate project objectives and analyse alternatives	1/2
	3. Align project objectives with Adaption Fund strategic outcomes	-
	4. Include project indicators and select core Adaption Fund indicators	3
	5. Set targets	-
	6. Monitor data	4
	7. Review and report data	4
Urban Climate Action Impacts Framework (UCAIF)	1. Actions	1/2
	2. Outputs	1/2
	3. Outcomes	1/2
	4. Impacts	1/2
	5. Indicators	3

Appendix B
Individual case studies

Icons indicating climate hazards targeted by each case study


Surface water flooding


Drought


Riverine flooding


Landslides


Extreme heat


Noise


Wind


Air quality


Storms


Amenity (co-benefit)

Other icons


Success factors


Challenges

GL – Glasgow City Region

GL1 – White Cart Water Flood Protection Scheme

Description – what did the project do?

White Cart is a £53m series of flood risk management projects developed by Glasgow City Council and delivered in three phases between 2008 and 2018. The projects are located along the White Cart Water, a tributary to the River Cart, in turn a tributary to the River Clyde, which is the biggest river in Scotland. The project involves forming three flood storage areas upstream of Glasgow to temporarily hold back the bulk of floodwater generated by extreme rainfall and control the release of water passing downstream through the city to an acceptable level, as well as flood defences, in the form of low walls and embankments, are also being constructed in selected parts of the river corridor through the city.

The project was conceived specifically as an adaptation project to reduce the risks from extreme weather and rainfall events. The project was designed to address the current problem but also looked at climate change projections to build in capacity and to future-proof the project. As part of scoping, several cost benefit analyses were carried out. On the basis of flood damages that occurred during 2006/07 it was projected that flood damage cost would rise to more than £100M over the next 15 year compared to a £53m investment in the White Cart flood management scheme to significantly reduce the risk of flooding for the foreseeable future.

Phase 1 of the scheme saw the construction of three large dams and storage areas to protect against a 1-in-200 storm event, reducing the river flow by 2.6 million m^3. Phase 2 comprised the construction of 4.5km of flood defence walls and embankments in Glasgow along sections of the White Cart Water and Auldhouse Burn in the south side of the city, together with the raising of two footbridges and the construction of six underground pumping stations.

Phase 1 and 2 were completed in 2012. However, not all of the originally planned work could be implemented due to lack of funding, meaning a further, follow-on phase was needed. Phase 3 started in 2016 and is currently under construction. It involves the construction of nine sections of concrete-clad flood defence wall and earth embankments which will provide direct flood defence along sections of both the White Cart Water and Auldhouse Burn. Two below ground stormwater pumping stations will also be installed to deliver water from the 'dry' side back into the river channel at times of high river level when gravity drainage is not available.

Project owner: Glasgow City Council.

Project budget and funder: £53m.

The scheme was to be 80% funded by the Scottish Government, with the remaining 20% coming from Glasgow City Council. However, changes in funding rules initially lead to a shortfall of funding, leading to the follow on work in phase 3.

Level of confidence that risk reduction has been achieved as a direct result of the project:

High – Modelling and monitoring data from a heavy rainfall event.

Elements of climate risk the project sought to address

EXPOSURE

Yes – the project looked to specifically reduce the risks from extreme weather and rainfall events.

SENSITIVITY

No.

ADAPTIVE CAPACITY

No.

GL1 – White Cart Water Flood Protection Scheme

Approach to monitoring and evaluating consequences

Extensive monitoring of river flow rates and amounts detained in flood storage areas during severe rainfall events. This data gathered and additional water flow modelling carried out allowed the calculation of how many properties were protected from flooding and what damages were avoided during a specific storm event.

Reported and/or observed consequences

ACTIONS	OUTPUTS	OUTCOMES	IMPACTS
Creation of storage areas and hydro-brakes. Building of flood defence walls and embankments.	Three large dams and storage areas to protect against a 1-in-200 storm event. 4.5km of flood defence walls and embankments. Two footbridges raised. Six underground pumping stations.	It has been estimated that up to 7,200 homes and 40 businesses have been protected from flooding.	Initial assessments indicate the scheme avoided damages of £20m in the first three years to 2011/12. Increase in property values and number of properties for which flood insurance can be obtained (extent of increase not provided)

Project success factors and challenges

- ⊕ Establishing the best possible communication with the public and other stakeholders as early as possible. A collaborative approach through solid consultation and communication processes was critical to build trust and ultimately lead to the success of the project. It was important to build close partnerships and engage with specific interest groups, e.g. it proved beneficial to engage an agricultural specialist who could engage well with specific landowners.
- ⊕ Being able to show added value to interested parties, e.g. by demonstrating to allotment owners that work carried out with actually improve the quality of the allotment area
- ⊖ Lack of comprehensive knowledge of some of the underground utility services. Searches and trial digs were carried out but there still several surprises encountered during the building and implementation phase.
- ⊖ Some issues with people wanting to protect individual trees that had to be removed to implement the scheme, despite the fact that 7,500 trees were planted as part of the scheme, compared to the 1,000 that had to be re-moved to allow the project to be carried out.

GL2 – Seven Lochs Wetland Park and Green Network Strategy

Description – what did the project do?

The Seven Lochs Wetland Park is a partnership developing and establishing Scotland's largest urban nature park (17km^2) on the boundaries of Glasgow and North Lanarkshire as a new visitor attraction as well as for use by local communities. The project encompasses heritage restoration, trails for recreation, and habitats protection, with the aims of protecting and enhancing biodiversity and heritage, promoting health and well-being, and contributing to environmental, economic and social regeneration. The project also has a secondary of improving the quality of new housing in the area, facilitating higher standards for SDS and green space.

Although conceived as a heritage and nature project, a major component involves creating a multifunctional network of green spaces from green belt in Glasgow and North Lanarkshire through areas of planned development to the more urban areas in the park. It is this element which has the strongest links to adaptation and mitigation.

The project did not specifically focus on adaptation. On the Glasgow side of the park, surface water management networks were already at capacity, so any future development needed to consider wider changes to the drainage network, and the role Green Infrastructure should play in that. As part of the project development, a hydrological scoping study was conducted to quantify the impacts of major development in that area. Subsequently a more detailed study was undertaken considered flooding with an uplift included to account for climate change, to inform development of a surface water management plan which was put in place to mitigate future risk.

Work has extended past the park boundary into surrounding projects, extending the park onto people's doorsteps. Extensions specifically focus on surface water management in those green corridors to enable development of adjacent vacant and derelict land. The partnership has also secured Peatland Action Grants for restoration in the site to also help manage the store of water. These have focused on sites in direct control of public landowners, but there is a longer term aspiration of engaging private sector owners.

Project owner: The project brings together Glasgow City Council, North Lanarkshire Council, Scottish Natural Heritage, and Forestry Commission Scotland as well as TCV Scotland and two local community development trusts.

Project budget and funder: £4.5 million Heritage Lottery Fund grant in 2016.

Level of confidence that risk reduction has been achieved as a direct result of the project:

Medium.

Elements of climate risk the project sought to address

EXPOSURE

Yes, the project is aiming to reduce direct downstream flood risk as well as the enabling of new development in the City Region.

SENSITIVITY

No, although the creation of integrated green networks may help nature to adapt.

ADAPTIVE CAPACITY

No.

GL2 – Seven Lochs Wetland Park and Green Network Strategy

Approach to monitoring and evaluating consequences

The project used flood risk modelling to evaluate the impacts of new development, and develop adaptation options as part of the surface water management plan. In addition, three of the four peatland sites earmarked for restoration have had ongoing hydrological monitoring installed, with a plan to conduct hydrological modelling to see if the work is having an impact and to use in reporting.

Reported and/or observed consequences

ACTIONS	OUTPUTS	OUTCOMES	IMPACTS
Development of a partnership vision and masterplan	Habitat conservation and maintenance	Broader Green Network connectivity	Not possible to assess based on available data.
Hydrological Studies	Events and recreation	Enabled housing development for 4,500 homes	
Submission of funding bids.	ERDF SNH Green Infrastructure Fund application	Restoration of vacant and derelict land.	
	Peatland restoration.		

Project success factors and challenges

- Changes in staffing requires constant engagement to maintain influence and realise opportunities. This can be mitigated by embedding commitments into plans and using advisory groups.
- Capacity was needed to develop all relationships on site management and planning. Management was a natural focus but better engagement with planning could have led to further opportunities.
- Core funding – the funding for park delivery required a holistic approach to thinking about economic, social and environmental benefits of heritage outcomes. Now secured, that thinking allowed the partnership to extend activities to reach the outcomes.
- Long term commitment, space for innovation and seed funding – the project took a long time to go from development to implementation and would not have happened without the GCV Green Network Partnership having the ability to take something like this on and put in that development time.
- Collaboration – a strong emphasis was placed on collaboration and securing commitment and buy in. This enabled a partnership to be established and which saw the wider opportunity and was able to bring capacity through a range of funds.

GL3 – Climate Ready Clyde (CRC)

Description – what did the project do?

A partnership initiative of 13 different institutions, pooling their own funding to deliver a regional climate change adaptation strategy and action plan, supported by a climate risk and opportunity assessment. The work is delivered by Sniffer, which runs a secretariat comprising 1.45 FTE per year (project manager and coordinator), as well as a small budget for ousourced research, communications and expenses. It provides technical capacity-building support within member organisations, as well as 'climate leadership' by responding to key developments in the City Region, and consultations, as well as representing the City Region on a global stage and learning from the work of others to inform work in the City Region. The concept for the programme started in 2012 and came out of the Adaptation Scotland programme and an acknowledgement that adaptation should be placebased. It started with a vision for a resilient Clyde which was endorsed by a number of local partners, with the grant funding being used to scope the current and implement the model of pooling funding in April 2017.

Project owner: Climate Ready Clyde Board – 13 different partners.

Project budget and funder:

Partners contributing equal annual funding of ~£7,250: University of Strathclyde, Scottish EPA, Transport Scotland, Strathclyde Partnership for Transport, Scottish Gas Networks, Glasgow City Council, South Lanarkshire Council, North Lanarkshire Council, West Dunbartonshire Council, East Dunbartonshire Council, East Renfrewshire Council, NHS Greater Glasgow and Clyde, and University of Glasgow. Scottish Government provided core funding the £100,000 start-up costs for the partnership. The initial aim for funding was to make an EU LIFE funding bid, but this was not pursued partly due to uncertainty following the UK referendum on the EU.

Level of confidence that risk reduction has been achieved as a direct result of the project:

Medium, chiefly through its influence on projects delivered by other organisations in the region. While CRC can demonstrate a range of outputs and the funding pooling model is a strong example of extracting value from limited adaptation funding, there is limited other evidence to support a firm conclusion about risk reduction achieved through other CRC activities to date. However, undertaking a regional climate risk assessment may lay the foundation for assessing how risk to the region evolves over time.

Elements of climate risk the project sought to address

EXPOSURE

Yes, although through development of the evidence base rather than direct implementation of physical interventions. The project is looking at exposure as part of its work to produce a climate risk assessment for the region. This assessment is based around the sections of the CCRA2, and other national and local evidence to summarise key risks to the region.

SENSITIVITY

Yes, through the risk assessment for the city region.

ADAPTIVE CAPACITY

Yes. CRC's work is about improving the ability of member organisations to adapt their operations in response to climate change.

GL3 – Climate Ready Clyde (CRC)

Approach to monitoring and evaluating consequences

So far, M&E of CRC has focused on collating data on activities undertaken and outputs generated. To date these have been summarised in one public annual report.

Much of CRC's work is currently around assembling the evidence base around climate risk to Glasgow City Region. Once complete, this will leave it better placed to measure changes in risk over time, although it may still prove difficult to determine the specific outcomes and impacts of CRC activities, given they occur in the context of a range of other actions and contextual factors.

Reported and/or observed consequences

ACTIONS

Undertaking and commissioning new research

Running stakeholder engagement and training events

Operating a secretariat function provides some direct technical support to members

Attending national and international events as a representative of the city region

Seeking to identify and obtain funding sources for adaptation work in the region

Helping to facilitate placement schemes for partner organisations – Offering the city as a test-bed for research programmes

OUTPUTS

20 representatives from 10 City Region organisations trained in adaptation skills and competencies

80 organisations engaged

Organisation-specific adaptation plans developed for six members with CRC support

New study (ongoing) into the economic costs of climate change for the region

Regional Adaptation Strategy and Action Plan supported by Climate Risk and Opportunity Assessment for the region (ongoing)

Business case guidance to support climate resilience outcomes in Glasgow City Region City Deal projects

Attracted £40,000 of additional Scottish Government funding for the region

Over 50 people attended Climate Justice training

£4.5m in research funding directed into the region. However it is difficult to conclude that all this funding has been secured as a direct result of CRC promoting Glasgow as a 'test bed' for adaptation.

OUTCOMES

Influence over future development projects underway in the region (e.g. the need to understand flood risk exposure of proposed locations for new electric vehicle charging stations).

Contributed to Glasgow's selection in the 100 Resilient Cities network.

IMPACTS

Improved awareness of climate risk among those planning future development in the region. This may potentially be leading to reduced risk to climate hazards, although it is difficult to determine at this relatively early stage.

Project success factors and challenges

- (+) CRC established a prospectus for the partnership around the economic imperative for adaptation, including reference to issues around value-for-money, efficiency and climate justice (a key policy area for the Scottish Government). The prospectus was pitched at Chief Executive level personnel and included a covering letter from the relevant Scottish Government cabinet secretary. This approach has been credited with helping to attract partners.
- (+) Basing the case for action in the region around a strong evidence base, rather than as a moral imperative. For example, the ongoing economic study will give an objective view of the expected impacts of climate change on GVA, which can be used by organisations in the region to support their own adaptation decision-making.
- (+) Careful consideration was given to where the partnership would sit alongside existing partnerships and efforts.
- (+) Pooling small discrete budgets can generate more activity and value than if these budgets are managed organisation by organisation.
- (–) In undertaking the regional risk and opportunity assessment, CRC has realised the difficulty in seeking to arrive at stakeholder consensus on numerical risk scores. It has therefore focused on using similar risk categories to the UK CCRA (e.g. 'research priority', 'watching brief').

LO – Greater London

LO1 – London Climate Change Partnership

Description – what did the project do?

Established in 2002, London Climate Change Partnership (LCCP) is a forum for knowledge exchange between the scientific community, policy makers, and practitioners working in London. Comprising a Secretariat function delivered by the Partnership Manager, and a core Steering Group spanning the academic, public, private and third sectors, it convenes events and advises on policy. Initially the LCCP was based within the environment team of the Greater London Authority (GLA). From 2010 to April 2017 the Partnership Manager sat within the Environment Agency, before returning to the GLA.

'Members' must actively agree to Terms of Reference but are not required to pay any subscription fee; those involved from time to time in the LCCP's activities are termed 'partners'. The intent is for members to collectively decide on the direction and activities of the partnership. The partnership does not seek to engage directly with the general public, but it may provide guidance to member and partner organisations about how to approach public engagement activities.

In the new London Environment Strategy, the LCCP has been tasked with monitoring London's adaptation progress. It is currently working with partners to develop a framework for monitoring that is applicable across different sectors.

Project owner: Greater London Authority.

Project budget and funder: GLA funding is primarily for the role of a full-time Partnership Manager.

Level of confidence that risk reduction has been achieved as a direct result of the project:

Low, although this should not be taken to mean the partnership is not worthwhile. Partnerships such as LCCP are extremely important for linking the disparate actors with roles to play in urban adaptation; however, there is a lack of data upon which an assessment of impact can be based.

Elements of climate risk the project sought to address

EXPOSURE

Yes, indirectly by supporting/ influencing the actions of others through networking and information provision.

SENSITIVITY

Yes, indirectly by supporting/ influencing the actions of others through networking and information provision.

ADAPTIVE CAPACITY

Yes. The LCCP's primary function to improve the capacity of members and partners to adapt effectively to climate change.

LO1 – London Climate Change Partnership

Approach to monitoring and evaluating consequences

While LCCP is able to gather data from its records on outputs (e.g. number of partners attending events), it does not adopt a structured approach to measuring outcomes and impact. It was noted in interviews that it can be a challenge making the case that partnership working is valuable in itself; in part this is due to the methodological difficulty in clearly attributing outcomes to specific networking and knowledge sharing activities, and also dedicating more scarce resources such an exercise may diminish the LCCP's ability to undertake its core function.

Despite the lack of concrete evidence of impact, it was also suggested that the GLA and partners understand the value of the partnership and that ongoing active participation by members is a useful proxy indicator of success. This is evidenced by the LCCP being explicitly tasked by the Mayor of London to monitor adaptation progress.

Reported and/or observed consequences

ACTIONS

Regularly convening a core Steering Group

Convening separate working groups around Communications and Heat Risk

Providing ad-hoc advice and support to partner organisations

Sharing information with members and partners about expected climate change, its impacts on London and examples of suitable adaptation actions

Delivering specific projects and commissioning research, where appropriate.

OUTPUTS

Supported member organisations to convene adaptation-related events with their own stakeholders (e.g. Thames Estuary Partnership)

Periodic meetings, workshops, training for members and partners.

Public resources on adaptation, such as 'Retrofitting London – Guidance for social housing projects'.

Adaptation monitoring framework for London (under development).

OUTCOMES

New connections facilitated between members or organisations participating events run by the partnership. For example, a student approached LCCP, which connected her with TfL. This led to the student undertaking research on overheating which has led to further work and potentially inform tangible interventions.

Building capacity of partners and members to act as 'champions' for adaptation within their own organisations (e.g. TfL).

Providing a platform for London partners to connect with national resources (e.g. Met Office climate projections).

Contributing to public discourse and building the case for greater action in the area of adaptation.

IMPACTS

Difficult to assess at this time.

Project success factors and challenges

- ⊕ Support for the Partnership from the Mayoral level, as well as strong champions within the cohort or members and partners.
- ⊕ Clear and concise communication with members and partners – being clear about the purpose of activities, making sure that they 'get something' from participating and there is follow-up after events.
- ⊖ The LCCP is an established, trusted forum for working across sectors; however, it was reported in some interviews that the Steering Group lacks adequate representation from the business community. However, the point was also made that 'business' is extremely diverse in terms of the products, services and functions being undertaken that could be influenced by climate change.
- ⊖ It was suggested by some interviewees that the partnership's focus can be excessively academic at the expense of scoping clear projects the LCCP can seek funding for and deliver.

LO2 – Crown Woods Way

Description – what did the project do?

This project was a SDS scheme located in at the intersection of a residential street and the A2 highway in south-east London. It was not explicitly scoped as a climate change adaptation initiative – the primary objective was to improve drainage within a Critical Drainage Area, but other objectives included improving residential amenity, local air quality and attenuating traffic noise generated by vehicles on the A2. The interviewee reported that all these considerations helped for the case for the project to go ahead – existing data sources such as King's College London air pollution monitoring station and Department of Transport noise modelling were both used.

This project was intended to demonstrate replicability – a key part of this approach was only using standard construction materials and simple designs that could be readily sourced and repeated by others. A relatively high level of resident engagement was undertaken for this project, led by the non-profit organisation Trees for Cities.

Project owner: Royal London Borough of Greenwich, involvement from Trees for Cities.

Project budget and funder: Total project value approximately £22,000. £5,000 from GLA, remainder from Borough.

Level of confidence that risk reduction has been achieved as a direct result of the project:

Medium confidence of risk reduction on a local scale (i.e. for residents Crown Woods Way).

Elements of climate risk the project sought to address

EXPOSURE

Yes, site identified as within a Critical Drainage Area – project aiming to reduce localised exposure of street and residents to flooding events.

SENSITIVITY

Yes, a key focus. Installation of SDS intended to make Crown Woods Way better able to cope with extreme rainfall events when exposed, as well as improve quality of runoff.

ADAPTIVE CAPACITY

No.

LO2 – Crown Woods Way

Approach to monitoring and evaluating consequences

As this was a small scheme delivered on a tight budget, M&E was not prioritised highly. The interviewee reported that anecdotal observations from recent severe rainfall events indicate the scheme is working as intended. The borough has also relied on incidental observations from residents to monitoring the overall success of the scheme – responses have been overwhelmingly positive, although residents observed motorists driving over installation to access Crown Woods Way, requiring a fire gate to be installed retrospectively.

Reported and/or observed consequences

ACTIONS	OUTPUTS	OUTCOMES	IMPACTS
Installing new SDS measures, including trees planted using Stockholm planting principles, raingardens and new Lambeth SDS grass verges.	10 trees (Birch and Fastigate Oak) and raingarden installed. Two rain gardens spanning the cul-de-sac of Crown Woods Way abutting the A2. New kerb and channel drainage and extended grass verges.	Drainage capacity of the street increased to handle 1-in-100 year event, whereas previously flooding may occur in in 1-in-15 year event (conclusion based on ex ante design, not ex post monitoring). Anecdotally there have been no flooding issues since installation. Runoff quality may have improved but has not been actively measured.	In addition to reduced localised flooding risk, there have been anecdotal reports from residents around improved visual amenity and perceptions that road noise levels have improved (no quantitative data to support).

Project success factors and challenges

- The interviewee spoke very highly of the involvement of Trees for Cities, which led stakeholder engagement activities such as letterbox drops.
- Early involvement from tree specialists in species selection was viewed as a key contributor to the scheme's success. This came at no cost to the proponent by requesting ad-hoc peer review of plans from organisations such as Barcham Trees and Trees for Cities.
- It was reported that, through taking the time to communicate about the project, it has helped demonstrate the merits of SDS among project managers within the Borough Council, who are now more able to identify opportunities to incorporate SDS into projects.

LO3 – Climate-proofing Social Housing Landscapes

Description – what did the project do?

This project sought to demonstrate how retrofitting open spaces on housing estates can be a cost effective solution to improving London's resilience to climate change. It involved design and implementation of open space adaptation schemes on three housing estates, incorporating green roofs and integrated SDS. Unlike the majority of projects considered in this study, climate adaptation was an explicit objective at the outset.

Project onwer: Groundwork, in partnership with Hammersmith & Fulham Council.

Project budget and funder: Total project value around £1.5m – 60% EU LIFE funding, 40% matched funding from Borough, GLA.

Level of confidence that risk reduction has been achieved as a direct result of the project:

High confidence of risk reduction on a local scale (i.e. for residents of the three estates, particularly those living at ground level).

At a borough and city-wide scale, the impact of this project on drainage capacity issues will be negligible unless similar interventions are implemented at a larger scale.

Elements of climate risk the project sought to address

EXPOSURE

Yes, SDS interventions are intended to reduce the likelihood that sites are exposed to a flooding event; however, they were not intended to address exogenous causes of flooding (e.g. constrained capacity in broader drainage networks; the occurrence of storm events).

SENSITIVITY

Yes, a key focus. Installation of SDS intended to make sites less sensitive to extreme rainfall/heat events.

ADAPTIVE CAPACITY

Indirectly. Engaging with communities around climate change may build their own capacity to adapt more effectively. See capacity building below for more detail.

LO3 – Climate-proofing Social Housing Landscapes

Approach to monitoring and evaluating consequences

M&E was prioritised highly in this project, much of which was undertaken by University of East London. Interviewees reported the following activities were undertaken:

- Use of thermal cameras near green walls and roofs to measure changes in heat due to greening.
- Installing flow meters on downpipes, weather stations, pressure sensors in some features; time lapse cameras focusing on some features; installation of weather stations at each estate.
- Ecological surveying on green roofs and also in some of the features at ground level.
- Conducting a controlled trial of one feature by creating a 'simulated flooding event' using a large tank of treated water provided by Thames Water. Testing took place up to the equivalent of a 1-in-100 year event plus an allowance for climate change.
- Assessed wider impacts using a Social Return on Investment Model designed by the New Economics Foundation

Project proponents report between 10 and 15% of the total project budget was directed towards M&E. Some of the activities are ongoing.

Reported and/or observed consequences

ACTIONS

Installing SDS features across three council estates.

Providing 'Green Doctor' visits to identify internal building energy efficiency opportunities.

Delivering accompanying programme of training and stakeholder engagement.

Undertaking a dedicated programme of monitoring and evaluation (as per funder requirements).

OUTPUTS

3,158m^2 impermeable surface renaturalised.

4,537m^2 land 'improved'.

24m^2 of growing beds installed.

432m^2 green roofs installed.

11 jobs created during project duration.

22 people employed as green team trainees.

46 council and contractor staff trained.

Two annual monitoring reports.

Social Return on Investment Report.

Shareable M&E data.

OUTCOMES

100% of rainfall on estates being diverted from drains – found to represent 1,286,815L diverted annually.

Retrofits provided reported to have GHG savings of 6.2 tonnes/year.

Small contribution to local employment; development of new skills.

Raised awareness of potential benefits of SDS.

IMPACTS

Modelling by New Economics Foundation found benefit for every £1 invested in a range between £2.31 and £5.15, when taking into account broader social benefits.

GHG reduction impact negligible; data not available to assess any broader benefits of 'Green Doctor' visits.

M&E data highly valued by third parties, e.g. Thames Water. Programme has led to funding of further green infrastructure work with boroughs.

Project success factors and challenges

- (+) M&E was treated as a key aspect of the project, as opposed to a 'nice to have' activity if time and funds permit. This has helped to communicate the benefits and influence the work of others.
- (+) The project prioritised working with communities where past work had been done and existing relationships were established. Groundwork operating as lead agency may also have helped to circumvent potential reluctance among residents to engage with a Borough Council.
- (+) The project established a strong and effective Steering Group.
- (–) Interviewees reported that, a stronger baseline would have been available if monitoring had been commissioned to start earlier in the project. The slow start meant that, rather than compare ex ante and ex post data from the same estate, it was often necessary to compare monitoring data in adjacent estates where no interventions had been implemented.

GM – Greater Manchester

GM1 – Water Resilient Cities Pilot

Description – what did the project do?

Business in the Community's Water Task Force convened a group including to develop a scalable model to deliver the financial and multiple benefits of Green Infrastructure on a site by site basis and City Region level.

The project was identified when United Utilities implemented new Ofwat guidance on water charging, resulting in charging non-domestic properties separately for drinking and waste water. The changes in charging meant BITC saw it as an opportunity to incentivise investing in SDS to support resilience. The project secured funding from BITC for an initial feasibility study which established the fundamental business model of a financial ROI for SDS within charging structure. A second stage study was funded through DEFRA's Urban Pioneers programme and focused on quantifying the multiple benefits that could be generated in taking such an approach. The project also piloted implementing at two sites (a school in Trafford, and an NHS site in Stockport), with a view to understanding hidden costs associated with structure and delivery. These are being used to refine the model further. The project team has also been working with the sties to raise awareness of GI and use sites used as an educational tool.

The work generated two models for Greater Manchester The first was based on sites that savings greater than costs only and showed that there was potential to undertake SDS retrofit at 248 schools and 5 NHS sites. Here the total cost was about £1.2m and total savings over 5 years £2.2m. With multiple benefits included at £1m, the total benefits were £3.2m. The second model explored where some sites might deliver some benefits and whether it was possible to offset the cost of some sites where sites where we do. In this model the group identified the possibility to undertake SDS retrofit in 569 sites (552 schools, 17 NHS sites) with a total cost (capital and operational) of £3.7m, total financial savings around £3.7m, additional benefits around £3.1m, delivering £6.8m in total benefits. The taskforce is now continuing work to develop and roll out the model across Greater Manchester.

Project owner: Business in the Community.

Project budget and funder: BITC member funding, with some contribution from United Utilities.

Level of confidence that risk reduction has been achieved as a direct result of the project:

Medium at the pilot sites; unknown at this stage for the broader roll-out.

Elements of climate risk the project sought to address

EXPOSURE

Potentially, although SDS on this scale are more likely to reduce a site's sensitivity to a flood event.

SENSITIVITY

Yes, a key focus. Installation of SDS intended to make sites less sensitive to extreme rainfall/heat events.

ADAPTIVE CAPACITY

Yes, but only to the extent of engaging with local stakeholders throughout the process. However, the programme model suggests the potential to extend the ability of the City Region to increase the ability to prepare for extreme weather events beyond what was originally envisaged.

GM1 – Water Resilient Cities Pilot

Approach to monitoring and evaluating consequences

The project used the CIRIA Benefits of SuDS tool as part of the modelling to estimate the impact and benefits for mental health, education benefits, property value, carbon storage, heat island effect, but also flooding and water quality. BITC have been talking to demonstration site owners about the potential to undertake citizen science monitoring with the Wildfowl and Wetland Trust.

The interviewee noted that that whilst individual projects will deliver risk reduction, and that they are confident that are contributing to a benefit in these areas, it became harder to quantify their role in wider City-scale resilience due to the broader changes in an area, and the need for scale.

Reported and/or observed consequences

ACTIONS	OUTPUTS	OUTCOMES	IMPACTS
Two pilot SDS sites implemented.	Project reports SDS Audit Guide Site model Programme model.	An invest-to save project for Greater Manchester	Risk reduction on pilot sites. High potential for risk reduction, cost savings and co-benefits based analysis of pilots, but realisation of promised benefits on a larger scale will depend on project roll-out.

Project success factors and challenges

- ⊕ A supportive political environment through the GM Mayor helped identify everyone's potential roles and responsibilities. The ability to think strategically about delivering multiple benefits through one project was also key to success.
- ⊕ At the project level, stakeholders' ability and space to innovate and create change was cited as a key success factor. However, we heard that the current policy and funding structures for innovation around Green Infrastructure could be improved by focusing on system change instead of replicating traditional approaches.
- ⊖ There were a number of gaps in funding the project which meant the project has been heavily reliant on in-kind support from task force members.

GM2 – Manchester Climate Change Agency

Description – what did the project do?

Manchester Climate Change Agency is a private non-for profit organisation, facilitating a joint initiative between the private sector, third sector, academia and Manchester City Council. The agency is funded by MCC, private sector sponsors and funded projects (e.g. European Commission), with the original business case developed by MCC and the partnership board. The Agency was formed to support the delivery of Manchester's Climate Change Strategy, which focused on both mitigation and adaptation. It works in partnership with organisations across the City as a facilitator to enable that everyone in the city can participate in climate change actions by:

- facilitating public consultations and policy making
- establishing new partnerships to take climate actions
- promote and report on progress against the Strategy in an honest and transparent way.

It has worked in partnership with the University of Manchester to conducted assessment of climate change risk for the City, which is informing the strategy, but also directly delivers adaptation projects. Risk assessments have focused on both on local and global climate change risk, e.g. impacts on economy and health on a local level, but also maintaining global competitiveness in order not to be left behind by other cities.

Project owner: Manchester City Council.

Project budget and funder: Manchester City Council, private sector sponsors, and project-specific grants.

Level of confidence that risk reduction has been achieved as a direct result of the project:

Medium.

Elements of climate risk the project sought to address

EXPOSURE

Yes, indirectly by building capacity in the City. Reports track indicators in this area across Manchester.

SENSITIVITY

Yes, indirectly by building capacity in the City. Reports track indicators in this area across Manchester.

ADAPTIVE CAPACITY

Yes – the main role of the MCCA is to build capacity within the City to address climate change, with a view to then addressing exposure and sensitivity.

GM2 – Manchester Climate Change Agency

Approach to monitoring and evaluating consequences

The Agency has produced annual reports since 2010, which outline progress against the objectives set in the Manchester Climate Change Strategy (one of which is adaptation), and the themes of Buildings, Energy, Transport, Sustainable Production and Consumption, Blue and Green infrastructure. The report also showcases projects and activities by partners across the City.

The MCC Strategy has two headline indicators in its reports: the number and quality of resilience plans and adaptation strategies and the extent, quality and productivity of green spaces and tree cover. But they also measure indicators for themes such as CO_2 emissions, Cycling Levels, Modal share of car journeys, Food waste diverted back into food chain, the% Sites of Biological Importance (SBI) in positive management*, Number of Local Nature Reserves (LNR) and size in hectares (ha) and number of trees planted per annum. Whilst some of these are not directly related to adaptation it is important to note that some will indirectly contribute to adaptation by making it easier to prepare, respond and recover.

Reported and/or observed consequences

ACTIONS	OUTPUTS	OUTCOMES	IMPACTS
Facilitating public consultations and policy making Establishing new partnerships to take climate actions Promote and report on progress against the Strategy in an honest and transparent way.	Meetings, minutes, Board meetings, strategies and plans Funding bids – e.g. Horizon 2020 Manchester Climate Change Strategy 2050 Annual reports showcasing the progress made in terms of both projects delivered and key indicators on sensitivity. Reportedly engaged with over 100,000 people and hosted 10 international conferences.	£5m for new projects, including Grow Green, a Horizon 2020 project delivering green infrastructure on the ground Ongoing cross-sector senior governance of climate change in Manchester.	Not possible to quantify at this stage, but work has helped to develop a positive international reputation and recognition in this area.

Project success factors and challenges

- Collaboration / shared ownership – Foundation was laid in 2009, supported by campaign groups. Allowed to grow organically. A recognition that climate risk cannot be addressed by Local Authorities alone, and instead had to be shared and devolved responsibility for the whole of the city and to develop a long-term strategy .
- Political support.
- Core Funding - a success factor for delivery, but securing it is initially was a challenge. Having core funding has helped MCCA to reach its capacity and achieve its purpose (i.e. not being directed by projects). It also helps avoiding competing with partner organisations in the City to secure individual project funding.

GM3 – Roch River De-culverting

Description – what did the project do?

Forming one part of a broader £250 million urban regeneration programme, this project uncovered a section of the River Roch and an historic bridge, which was culverted and hidden beneath Rochdale town centre over a century earlier. A masterplan was drawn up for the town centre with the key aims of improving public realm, local transport infrastructure and services, as well as attracting investment in retail, leisure and business. At the same time the re-opening of the River Roch offered the opportunity to work with the EA to reduce current and future flood risk, meeting statutory requirements under the Water Framework Directive, improving natural habitat and increasing biodiversity. Although design of the scheme applied standard EA guidance around climate change allowances for planning, climate adaptation was not an explicit headline objective of the project.

Project owner: Rochdale Borough Council and Environment Agency.

Project budget and funder: £5 million, supported by Heritage Lottery Fund, Environment Agency and North West Regional Flood and Coastal Committee (through Local Levy funds).

Level of confidence that risk reduction has been achieved as a direct result of the project:

Medium. Observed functioning of scheme during Storm Eva indicates the scheme has reduced property exposure to flooding. However, the actual extent of risk reduction achieved cannot be assessed due to lack of formal ex post M&E.

Interviewee reported that opportunities to further reduce flood risk will be considered as part of comprehensive proposals being prepared by the Environment Agency and Rochdale BC between Littleborough and Rochdale Town Centre.

Elements of climate risk the project sought to address

EXPOSURE

Yes. Modelling as part of project design found the scheme would protect 40 previously vulnerable properties from flooding.

SENSITIVITY

Yes. Modelling found the scheme would improve drainage for 500 properties.

ADAPTIVE CAPACITY

No.

GM3 – Roch River De-culverting

Approach to monitoring and evaluating consequences

A comprehensive Environmental Impact Assessment was conducted for the project. As part of this, ex ante flood risk modelling provided evidence of quantifiable benefits the scheme was expected to deliver. Modelling of the expected economic benefits was also undertaken.

Based on interviews undertaken, it is understood there has not been any structured M&E ex post to assess the actual flood performance of the scheme. However, the consequences of Storm Eva on Boxing Day 2015 have been used as evidence of the effectiveness of the scheme. While the event did result in some property damage (business and residential) and transport disruption, it was reported that the scheme performed well and as designed in significantly reducing both the severity physical extent and the duration of the flooding event.

Reported and/or observed consequences

ACTIONS

Development of masterplan.

Analysis of flood risk and wider economic benefits expected.

Demolition of reinforced concrete capping the River Roch.

Works to re-establish as a 'natural' river.

Heritage restoration of bridge.

OUTPUTS

949m^2 of River Roch uncovered.

OUTCOMES

The scheme was modelled (ex ante) to generate flood protection for 40 properties and improved drainage for a further 500.

Reportedly reduced the impact of the Boxing Day floods in 2015 by helping to prevent flood water reaching the town hall. The flood outline and the area flooded was reduced and contained and many properties were saved from flooding, including the Town Hall.

Reopened river modelled (ex ante) to inject an extra £6.72 million into Rochdale's economy over a ten year period

Reported increase in business rate yield proximate to the development (figures not made available)

IMPACTS

Reduced flood risk in Rochdale Town Centre.

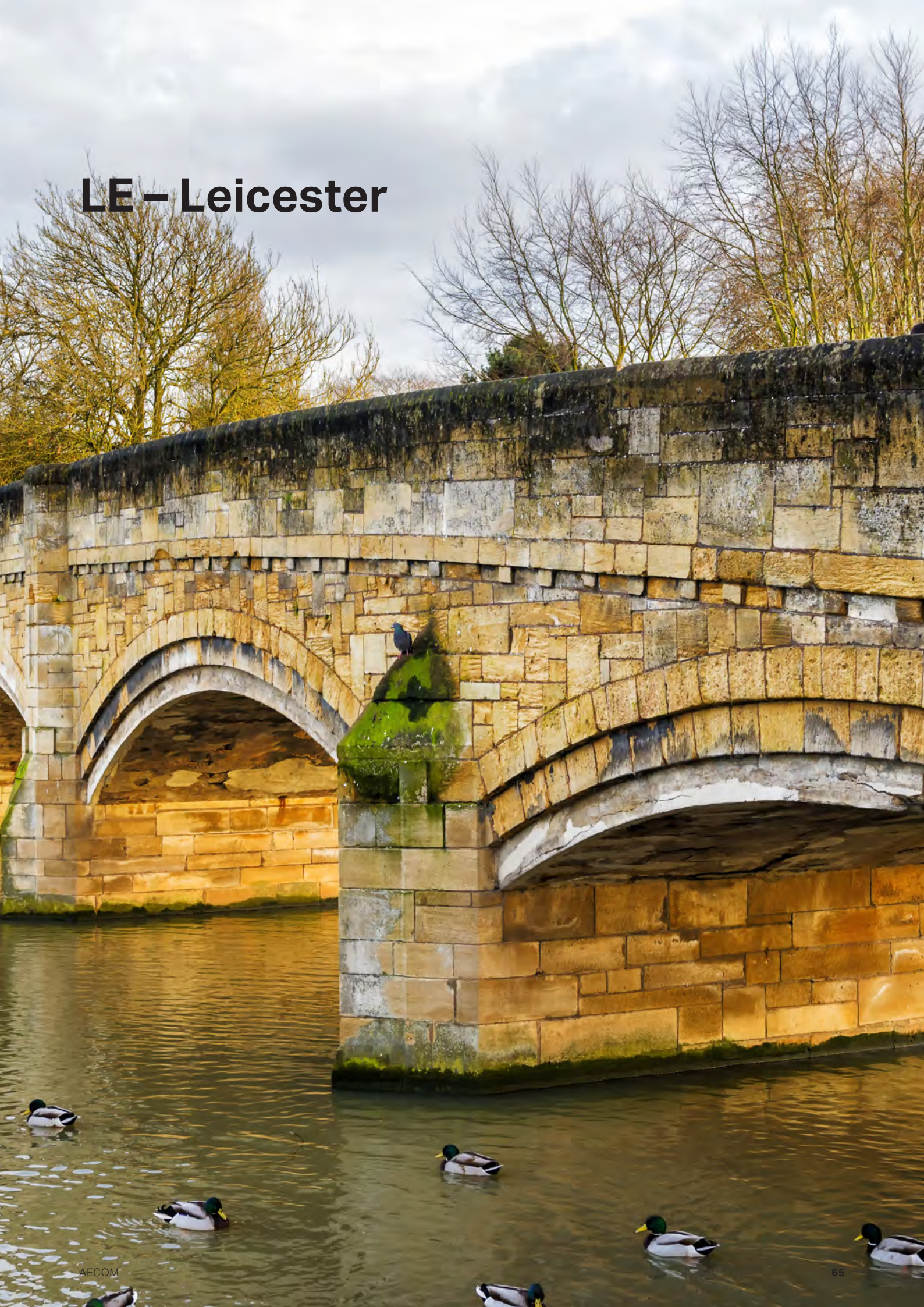
Anecdotal evidence that the successful delivery of the project has informed and influenced other flood risk and flood management schemes where the opening of a river could deliver benefits and enhance the local environment.

Positive public realm benefits.

Project success factors and challenges

- The EA allocated a dedicated and on-site officer for the project which provided efficient communication and continuity during the project delivery.
- Collaboration and good communication between the project partners and stakeholders was crucial to the scheme's success.
- A project steering group was established very early on in the process. The project group consisted of the EA, Historic England, United Utilities and Rochdale BC. There has been a comprehensive community engagement process with local residents, the business community and local schools. A dedicated Engagement Officer coordinated the community participation process as part of Heritage Lottery Fund requirements.
- The proposal gained political support from the outset and the project was able to convey a strong and positive message about the multiple benefits of the scheme for the whole town.

LE – Leicester



LE1 – Leicester SDS programme

Description – what did the project do?

The project involved establishment of an advisory group, comprising district and county councils, to inform developers in the Leicester area about using SDS. Running in parallel to the surface water management scheme (LE4), it is primarily a capacity-building project, comprising of stakeholder engagement through training workshops and the production of the Sustainable Drainage Guide.
The project has helped catalyse initiatives such as installing areas of permeable paving, swales, a connected rain guard scheme on Mill Lane, creating of Ellis Meadows and re-naturalising channels.

Project owner: Leicester City Council.

Project budget and funder: Leicester City Council.

Level of confidence that risk reduction has been achieved as a direct result of the project:

Medium. Difficult to quantify, because of the capacity-building-style of this project. However, there is a weight of projects that have been implemented in Leicester since the programme was developed, some of which have done their own analysis indicating a reduction in risk (e.g. Ellis Meadows reported to have led to protection of 1,200 properties from flooding).

Elements of climate risk the project sought to address

EXPOSURE

Indirectly only, through encouraging and enabling other actors to implement their own SDS initiatives.

SENSITIVITY

Indirectly only, through encouraging and enabling other actors to implement their own SDS initiatives.

ADAPTIVE CAPACITY

Yes. Capacity building is a key part of the programme and involves strengthening the knowledge base for taking to developers, by gathering evidence, and therefore having the ability to provide people with practicable options.

LE1 – Leicester SDS programme

Approach to monitoring and evaluating consequences

Evaluation of outcomes is not undertaken in a structured way. However, council is able to point to projects developed using the SDS guidance. In theory, more analysis could be undertaken of each project to understand the potential outcomes and impacts the guide has catalysed, although in many cases it would be difficult to conclusively determine the actual level of influence the guide had over the success of a given scheme.

Reported and/or observed consequences

ACTIONS	OUTPUTS	OUTCOMES	IMPACTS
Kick-off workshop Internal and external training sessions held to understand challenges/ constraints and educate stakeholders on SDS options and benefits Engagement with developers, SDS manufacturers and suppliers and relevant external bodies Visiting schools Stakeholder meetings Engagement with Severn Trent Water Development of guidance materials	The Sustainable Drainage Guide 2015 has been developed out of this project. Approximately 15 training sessions delivered to stakeholders external to Leicester City Council, each session to 20-30 attendees. Informal training sessions (two or three) held within Leicester City Council; each session for 30 attendees.	Project owners report that the guide has influenced the delivery of several successful SDS projects in the city; however, it is not possible to establish a clear link based on the evidence available. Two of the SDS schemes that have been implemented through the programme (Mill Lane and Ellis Meadows) have won industry awards in recognition of their approach to the use of SuDs in developments.	Theoretically reduced flooding risk, improved amenity for some Leicester residents and improved biodiversity proximate to some schemes. However, there is limited evidence to quantify the scale of impact. It was reported that this project has influenced projects beyond Leicester, with other local authorities adopting the guidance.

Project success factors and challenges

- Extensive and proactive stakeholder engagement has been cited as a key factor in this project's success.
- Having a policy and guidance in place has been cited as helping to justify and act as an evidence base for the use of SDS in new developments.

LE2 – Leicester Flood Risk Management Scheme

Description – what did the project do?

Leicester is ranked in the top five principal urban areas at risk of flooding – according to 'hot spot' modelling commissioned by the Environment Agency, around 7,000 residential and commercial properties at risk of river flooding, and more at risk of surface flooding.

Also known as the River Soar Flood Alleviation Scheme, this flood alleviation scheme works by removing barriers to flood conveyance and improving the capacity of the floodplain to store water. This draws water away from areas of built development by lowering flood levels. The project comprises of three phases of flood mitigation along the River Soar, with an overall aim to mitigate flooding in Leicester.

Phase 1 (completed in November 2014) involved utilising and re-profiling a recreational ground next to the river as a floodplain, ultimately increasing the river capacity. This increased the river flow through the existing flood arches in the Great Central Way Biam Bridge by lowering the ground level beneath the arches by approximately 1 metre.

Phase 2 (completed in December 2016) involved increasing the river capacity through re-profiling land and removing obstructions to increase the flood plain and regulate flow capacities, including lowering public open spaces to enhance their flood storage capacity and environmental amenity value. This work also involved the creation of a new wetland habitat (Ellis Meadow), which is an award winning 20-acre park and nature reserve which also acts as a natural defence, capable of holding water in the event of a flood.

Phase 3 is currently under construction and involves the creation of a floodwater bypass culvert through an embankment to the Loughborough Road Bridge to mitigate silting and flow issues. The new 5 metre-wide culvert will significantly increase the amount of floodwater that can pass under the bridge. Land on both sides of the bridge will also be lowered to create larger and more efficient natural floodplains. The culvert is being designed to also be used predominantly as a cycle path/ walkway in order to provide amenity benefits through the scheme.

Project owner: Joint Environment Agency and Leicester City Council, with some land owned by Co-operative.

Project budget and funder: Mostly funded by Flood Defence Grant-in-Aid (FDGiA) managed by the Environment Agency with the contribution of land and future maintenance provided by the City Council.

Level of confidence that risk reduction has been achieved as a direct result of the project:

High – monitoring has been undertaken to quantify extent of flood risk reduction, although overall benefits of the project not quantified.

Elements of climate risk the project sought to address

EXPOSURE

Yes, the project seeks to reduce exposure of residents and businesses to flooding.

SENSITIVITY

Yes, although the project is primarily about reducing exposure.

ADAPTIVE CAPACITY

Not directly.

LE2 – Leicester Flood Risk Management Scheme

Approach to monitoring and evaluating consequences

Modelling was carried out by the Environment Agency and their consultants at the start of the project and flood monitoring will carry on following completion of the works. An assessment has been carried out into how many houses have a reduced level of flood risk as a result of the scheme. The analysis found that Phase 1 (increasing river flow through the Great Central Way Biam Bridge) has reduced flood risk to 217 properties, while Phase 2 (Ellis Meadows Creation) has helped to protect 1,500 properties from flooding. Monitoring and maintenance of the schemes is ongoing.

Reported and/or observed consequences

ACTIONS	OUTPUTS	OUTCOMES	IMPACTS
Flood plain alteration (re-profiling and removing obstructions) Re-profiling of recreational land and public spaces Lowering of the ground level beneath bridge arches Creation of a new wetland 20-acre park and nature reserve (Ellis Meadow) Culvert construction Construction of public realm features, such as walking and cycling routes	Flood retention areas and improved floodplain characteristics A raised area protruding into the flood plain at Ellis Meadows was removed as part of the works to improve conveyance. Disused school playing fields were transformed into a 20-acre park and nature reserve (Ellis Meadow) 5 metre-wider culvert at the Loughborough Road Bridge	Phase 1 has reduced flood risk to 217 properties in Braunstone Town and Aylestone. Phase 2 is capable of holding water in flood event, which was found to protect 1,500 properties. Once complete, Phase 3 is expected to reduce flood risk to approximately 600 homes and businesses in the Belgrave area.	Reduced flood risk to properties and businesses. Co-benefits, such as improved residential amenity and opportunities for active and passive recreation. Disused public spaces have been transformed, public access improved and new habitat created along this important ecological corridor

Project success factors and challenges

- Close collaboration between Leicester City Council and the Environment Agency meant that approval to undertake the work was quickly secured and access to a flood defence grant was facilitated. This formalised relationship is also helping to facilitate monitoring, evaluation and maintenance of the project.
- There was very little opposition to the project due to the fact that most of the land was unused and owned either by the City Council or a private landowner (the Co-operative).

LE3 – Hamilton Housing Area

Description – what did the project do?

Originally constructed in the 1990s, making it one of the earliest large scale SDS schemes, this project is a housing development located in the Hamilton Community, to the north-east of Leicester. Flood risk in the area is evident and well documented, and therefore a requirement in the masterplanning process was to control the quantity of storm water entering Melton Brook. An objective was set to use sustainable methods of drainage to reduce flood risk and benefit the biodiversity of the area. The project sought to achieve this through the use of swales and wetland detention areas. These were viewed by developers as an aesthetically pleasing way to control the flow of water into Melton Brook.

Project owner: Leicester City Council.

Project budget and funder: unknown, funded by private developers.

Level of confidence that risk reduction has been achieved as a direct result of the project:

Medium. While there has not been formal ex post monitoring, the scheme's success in coping with severe rainfall events over a prolonged period provides strong evidence of its success in reducing flooding risk.

Elements of climate risk the project sought to address

EXPOSURE

Yes, use of flood control measures actively sought to reduce exposure of site and its residents to flooding.

SENSITIVITY

Yes, use of flood control measures actively sought to reduce site's sensitivity to flooding.

ADAPTIVE CAPACITY

No.

LE3 – Hamilton Housing Area

Approach to monitoring and evaluating consequences

Limited monitoring has been carried out since the project completion. However, observations and anecdotal evidence suggest that the scheme is still effective at present, but there is a lack of source control on the amount of water entering the swale system.

Reported and/or observed consequences

ACTIONS	OUTPUTS	OUTCOMES	IMPACTS
Inclusion of flood risk management measures in planning guidelines Design and delivery of SDS features, including ponds and swales	Housing development with swales and wetland detention area.	As far as the consultee was aware, the scheme has successfully detained flows during severe rainfall events since its construction.	Through long-term observations rather than structured monitoring: reduced flood risk for residents compared to a 'without project' scenario and improved biodiversity outcomes.

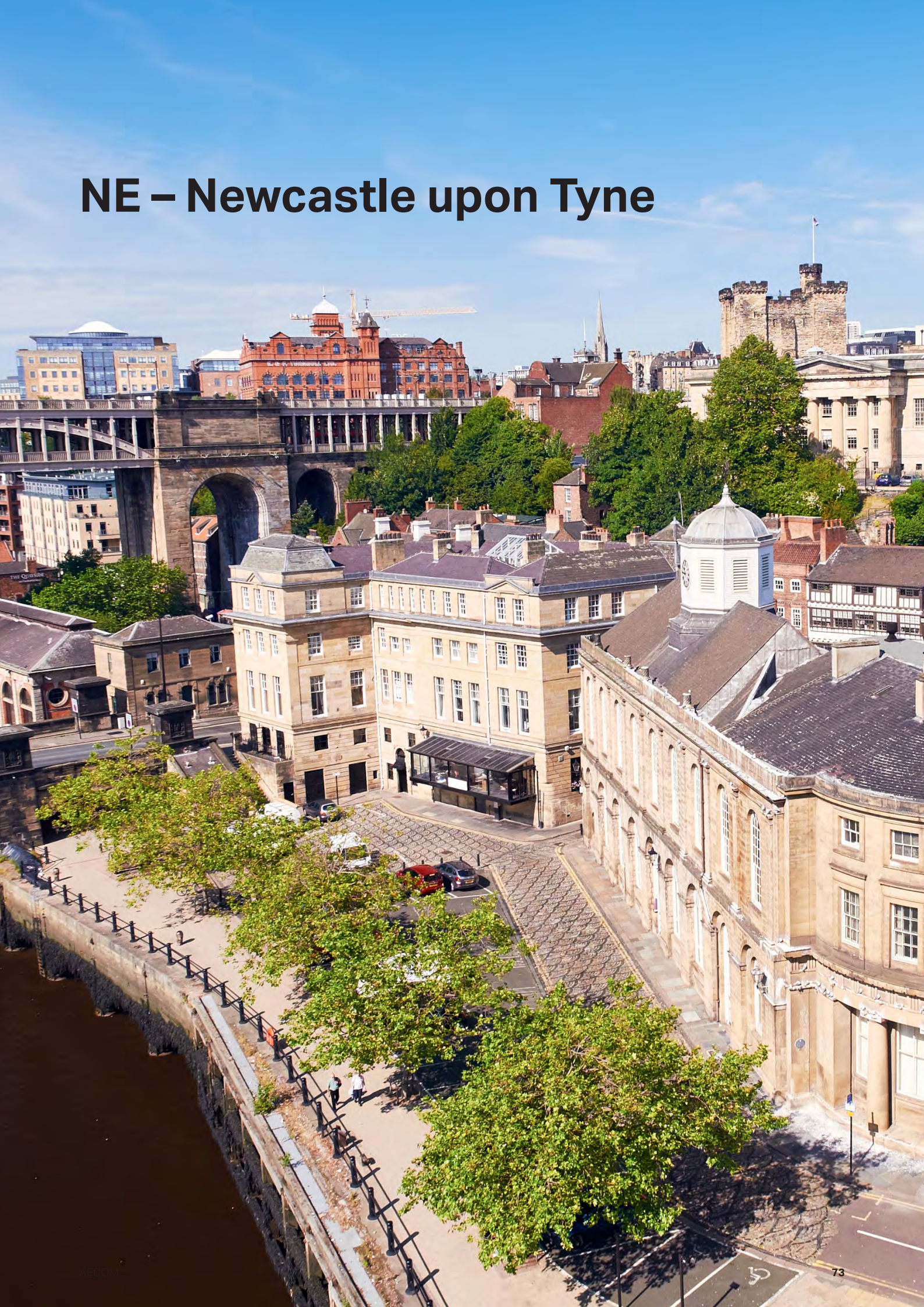
Project success factors and challenges

- (+) Inclusion of ponds with wide riparian vegetation has led to strong colonisation by invertebrates.

Follow-up review of the scheme found that:

- (−) A lack of source control means that the quantity of water entering the swale system is not limited, and has resulted in scouring and the need to use stone rip-rap and gabion mesh in the swales.
- (−) The gradient of the swale banks was potentially too steep. There were challenges associated with the requirement for the swales to pass beneath roads the designers opted for engineered head walls.
- (−) There is limited public access to the area, representing a missed opportunity for amenity and recreational benefits.

NE – Newcastle upon Tyne



NE1 – Newcastle Helix

Description – what did the project do?

Newcastle Helix is a 24 acre city-centre development, aiming to be an exemplar of sustainable urban living. The site is divided into 17 plots with different infrastructure, e.g. SDS and interlinking the infrastructure with the public realm, with the aim to promote science-led innovation in a wide spectrum of disciplines (e.g. digital, biological). The site is being developed in a three-way partnership between Newcastle City Council, Newcastle University and Legal and General Capital, and aims to create over 4,000 jobs with 500,000 sq. ft. of office space, and 650 new homes, facilitating significant economic growth in the city.

The original masterplan was revisited by consultants to improve management of surface water, informed by a partnership with Newcastle University, employing their 'CityCAT' model to design and test surface water management strategies and solutions, accounting for future climate change as part of an EPSRC funded project 'Blue Green Cities'. Following this process, a comprehensive site wide SDS strategy was developed to guide future development, and individual sites have been encouraged to include green, brown or blue roofs, collect and re-use rainwater, store water on plot below ground, use permeable paving and include surface water features

For example 'The Core' (which was the first building on the site and houses SMEs and start-ups) featured the tallest green wall in the UK. In addition to managing the flood risk, the aim was also to attract the public to spend time in the landscaped environment also looking at economic and health benefits of the development (public realm, community, shops, restaurants).

To continue to improve the climate resilience of the site, the City Council successfully secured Technical Assistance funding from the European Investment Bank to conduct a Climate Risk and Vulnerability Assessment for the site, in line with the EU Guidelines on Making Investments Climate Resilient. This work identified possible future areas for action around heat and wind, but also found an appropriate degree of climate resilience. The site has also focused on mitigation, establishing a District Energy Centre and Heat Network for the site, alongside a smart grid, and research into 'Carbon capture Gardens' to research which flora and fauna is best suited to reduce local carbon emissions.

Project owner: Newcastle City Council.

Project budget and funder: Private developers.

Level of confidence that risk reduction has been achieved as a direct result of the project:

Low at this stage, but may increase with time.

Elements of climate risk the project sought to address

EXPOSURE

Yes – the project looked to specifically reduce the risks from extreme weather and rainfall events, and some other climate hazards.

SENSITIVITY

Yes – consideration of the SDS strategy and green space.

ADAPTIVE CAPACITY

No – although the development of the site has raised awareness of the need to consider climate change issues in masterplanning, and this has been transferred to other sites (e.g. East Pilgrim Street).

NE1 – Newcastle Helix

Approach to monitoring and evaluating consequences

Long-term monitoring of the performance of the SDS will be undertaken through the University's Green Infrastructure Facility, and its role as an Urban Water Hub through the EPSRC's UK Collaboratorium for Research and Innovation in Cities.

Reported and/or observed consequences

ACTIONS	OUTPUTS	OUTCOMES	IMPACTS
Use of site as case study for future water management strategies by Newcastle University. Masterplan refresh Technical Assistance funds from EIB for Climate Risk and Vulnerability Assessment	Revised masterplan Recommendations for site development Application to EIB Natural Capital Finance Facility.	Green infrastructure-led public realm for surface water management Accelerated development.	While signs are promising, evidence at this stage of the development's life-cycle is not sufficient to draw firm conclusions about risk reduction impact.

Project success factors and challenges

- (+) Collaboration from the outset has been key to success, particularly the relationship between NCC and the university. The climate resilience of the site was only one small aspect of the wider development, and there was a significant engagement process with the public on the overall site considering the location in the city centre, with open days and coffee morning for the public and for business helping to overcome scepticism and convince the public of potential benefits.
- (+) A good communication strategy was critical to build and maintain relationships, with almost daily communication with developers and partners in an open and honest way to maintain collaboration across the site. Investing time and effort to deliver best practice.
- (–) The complexity and size of the development was a challenge, leading to differing timescales, with some buildings were in place before enabling infrastructure (e.g. District Energy Centre and pipework) was in the ground.
- (–) Financing the development and delivery of the sites has been challenging and complex. Initial enabling works were paid for through Newcastle City Deal, and the creation of an Accelerated Development Zone, allowing 100% retention of future business rates for 25 years, which helped unblock the initial financing. Since then, a mix grant funding, loans and private sector investment have been used to build out the site, with £5.6m of ERDF used to finance the development of The Core, whilst a partnership with Legal & General Capital has been used to develop an office development. The City Is now in the process of securing funds from the European Investment Bank's Natural Capital Finance Facility to continue delivery of the public realm and support the build out of the wider site.

NE2 – Brunton Park Flood Alleviation Scheme

Description – what did the project do?

Brunton Park Flood Alleviation Scheme is a £7 million joint flood reduction scheme aiming to reduce the risk of severe weather and storm events with associated extreme rainfall.

The scheme reduces the risk of flooding to more than 100 properties from sewer, river and surface water flooding in Brunton Park. The estate was built in the 1930s but was always prone to flash flooding from the River Ouseburn and surface water flooding due to the urbanised character of the development. Rain water run off quickly overwhelmed the combined sewer system. The ongoing flooding risk had consequences for the whole area; some property owners were unable to get home insurance and there was a risk that the area would experience a steady decline leading to deprivation. Northumbrian Water had assessed possible sewer flooding solutions since 2008 but none of the options explored were economical or fully solved the risk of flooding in the area. This led to the forming of a partnership between Northumbrian Water company, the Environment Agency and Newcastle City Council (NCC) to find a holistic and sustainable solution to protect the properties from flooding.

The scheme was scoped and designed mainly in partnership between the Northumbrian Water Group, the Environment Agency and NCC. Given the proposed use of their land for the scheme, the City of Newcastle Golf Club was also involved with some design work through a professional golf course designer.

The project began in October 2014 and completed in September 2016, with a community event, including children's activities and information stands as well as a wildlife area to find out more the wildlife in and around the River Ouseburn, as well as tours of the £7million scheme so residents could find out more about how the risk of flooding has been reduced.

The scheme was delivered by Northumbrian Water, marking the first time in the UK that a water company has done construction work on behalf of the Environment Agency. The innovative approaches in collaboration, design and delivery helped the project win the Sustainable Drainage and Flood Management Initiative award at the Water Industry Achievement Awards 2017.

Project owner: Northumbrian Water, the Environment Agency and Newcastle City Council.

Project budget and funder: £7 million – Northumbrian Water Group (ca. £6M) and the Environment Agency's Flood Defence Grant in Aid (FDGiA) (£1M).

Level of confidence that risk reduction has been achieved as a direct result of the project:

Medium – the rigour of the FDGiA process should mean that risk reduction benefits are delivered.

Elements of climate risk the project sought to address

EXPOSURE

Yes.

SENSITIVITY

No.

ADAPTIVE CAPACITY

No, although the process of conducing the project built the organisations' respective ability to collaborate for solutions to address risk.

NE2 – Brunton Park Flood Alleviation Scheme

Approach to monitoring and evaluating consequences

Both Northumbrian Water Limited and the Environment Agency are monitoring water flows and the performance of the infrastructure put in place for the scheme. There have been no reports of flooding since the scheme has been implemented NCC is therefore assuming that the scheme is delivering the expected benefits, although it is not clear if this is due to a lack of sufficiently heavy rainfall.

Reported and/or observed consequences

ACTIONS	OUTPUTS	OUTCOMES	IMPACTS
Employment of a golf course designer	380 metres of new river channel	New capacity to store 7.45 million litres of surface water.	Pluvial and fluvial flood risk reduction
Partnership approach to scheme design	650 metres of flood defences (walls and earth embankment)		Improved biodiversity
Apply for EA FDGiA	Two kilometres of new sewer pipe		Improved competitiveness of local golf course
Construction of the scheme.	New storage tank with 450,000 litre capacity		
	New play park built, in partnership with Newcastle City Council and the local community		
	Community event to celebrate construction.		

Project success factors and challenges

- The unique collaborative and constructive partnership between Northumbrian Water Ltd., the Environment Agency and NCC was important to find a holistic solution and deliver a sustainable outcome. This relationship had been built over a number of years across a range of projects, such as the Tyneside Sustainable Sewerage Pilot Study
- Innovative use of a golf course designer helped overcome some of the potential objections, recasting the changes as a potential benefit to the golf course.
- Engagement of a professional golf course designer right from the outset could have helped avoid initial scepticism and opposition to the part of the proposed scheme affecting the golf course site, in turn saving time and avoided delays in implementation.
- Being able to focus on the development of an integrated, partnership approach which benefits all parties means being able to put needs of all parties above those of individual organisational or company objectives, which is not always easy.

NE3 – Scrutiny Review

Description – what did the project do?

This case study is unique among those considered in this study, in that it relates to generation of organisational learning via a post-event review process following a series of major disruptive events. Following major flooding events in Newcastle during 2012 and collapse of a major culvert, leading to demolition of 18 properties, the City Council's Cabinet Member for Quality of Life agreed for an independent review to be conducted by the Newcastle City Council's (NCC) Overview and Scrutiny Committee. The committee agreed and worked with independent Council members to scrutinise statutory roles and actions undertaken by NCC personnel and partner organisations in responding to the events

The process consisted of a number of stages, including:

- An independent review of the response by a tutor in mass fatalities and pandemics who specialises in how communities recover after major events
- An event at which the public shared their experiences and find out about the work of emergency services
- A series of meetings with council officers and to understand how the response worked and could have been improved
- External meetings with Environment Agency, Tyne and Wear Metro, NHS England, Northumbrian Water, Newcastle North and East Clinical Commissioning Group, North East Ambulance Service.

This review led to 44 recommendations for changes to processes and procedures that were endorsed and adopted by NCC's Cabinet. Progress on implementation was then reported on publicly through the Cabinet process for a year. The recommendations were a mix of operational and strategic responses structured around emergency planning, multi-agency responses, Community Resilience, Communications and Culture Change and Infrastructure.

This case study is an example of a 'feedback loop'– something identified by the Rockefeller Foundation as an important part of increasing resilience – using intelligence to inform future responses. In this case, one of the recommendations agreed was for the Overview and Scrutiny committee to receive debriefs from future events and evaluate whether similar inquiries could be useful. Similarly, the work also acknowledged that the results from such reviews should also be fed back into longer term strategic planning across the City Council, and that climate adaptation should be considered as part of this.

Perhaps more relevant to this study is that the project is an example of 'transformative adaptation' where an extreme event creates a window for change and enables a City to accelerate its work on adaptation. For example, as part of receiving and endorsing the report, the City Council signed up to the European Environment Agency's Mayors Adapt programme, sustained a focus of the Council's Policy team on climate adaptation at a time of significant budget reduction and contributed to considerable expansion of the Council's Flood Management Team from 2.5 FTEs to 8, in turn expanding the capacity to develop and deliver the Council's flood risk capital programme.

Project owner: Newcastle City Council Overview and Scrutiny Committee.

Project budget and funder: Newcastle City Council; amount not specified.

Level of confidence that risk reduction has been achieved as a direct result of the project:

Low. The Scrutiny Review report contains a range of recommendations around climate change and flood risk reduction that have subsequently been implemented. However, it is difficult to determine conclusively how many of these actions would have subsequently taken place even if climate change had not been explicitly considered in the Scrutiny Review process.

Elements of climate risk the project sought to address

EXPOSURE

The review's Terms of Reference do not explicitly refer to flood exposure. The main focus of the review appeared to be emergency response.

SENSITIVITY

The review's Terms of Reference do not explicitly refer to flood exposure. However, the final report does reference flood risk schemes attempting to reduce the city's sensitivity to flooding.

ADAPTIVE CAPACITY

Yes. The review was an attempt to capture institutional learning that enables the organisation and local partners to adapt their approaches to flood risk management.

NE3 – Scrutiny Review

Approach to monitoring and evaluating consequences

This case study varies from others in that its main output was a list of recommendations. Where these were the responsibility of NCC to implement, progress was tracked through NCC governance and reporting processes. The official NCC cabinet response to the Scrutiny Committee's report explicitly acknowledges that 'measuring climate resilience is notoriously difficult, as achieving it is a continual process rather than a specific objective, with a long timescale of thirty years or more.' Following the 2012 events the NCC produced a climate change 'evidence base' document, including social metrics such as heat disadvantage; the city's progress against some of these metrics could theoretically be measured, but we are not aware of this having occurred.

Reported and/or observed consequences

ACTIONS	OUTPUTS	OUTCOMES	IMPACTS
Establish Terms of Reference focused on responding to future flood / emergency events Undertake review committee meetings. Conduct 29 stakeholder interviews. Review six existing policy documents and legislative framework.	Scrutiny Review report containing 44 recommendations.	NCC joined the Mayors Adapt initiative. Signed declaration committing to expanding use of blue-green infrastructure. NCC Flood Risk team expanded to 8 personnel between 2014 and early 2018 (difficult to conclude that this occurred as a direct consequence of the Scrutiny Review).	Anecdotally the review has led to a more proactive stance by NCC with regard to climate adaptation. It could also be argued that increased resourcing for flood risk managers improved the adaptive capacity of NCC.

Project success factors and challenges

- ⊕ Cross party political support for a review process and a 'no-fault' process emphasised in the terms of reference enabled more effective discussion of key issues and lessons learnt.
- ⊖ Review was conducted in a very short space of time, making scheduling and write up challenging.

Appendix C
Interview questions

Context and project development

- Please describe your project in your own words
- How was the need for this project identified?
- Was the project specifically conceived of as an 'adaptation project', i.e. conceived to address a specific climate change or severe weather risk?
- What risk assessment framework/methodology/ guidance was used to do this (if applicable)?
- Did historic and existing observed risks and impacts (e.g. past flooding) drive the decision to implement this project? Did future climate projections play a role?
- Were interdependencies and cascading consequences considered?
- How was the project scoped, designed and funded? Which other external organisations were involved?
- Were carbon/ greenhouse gas emission impacts and their reduction actively considered within the project?

Financing

- What process or processes were was used to assess the costs and benefits of the project, at the scoping, design and funding stage?
- Have private sector funds and/or EU grants been used? If so, please provide brief details.
- Were Green Finance or similar instruments or arrangements used to generate funding?

Monitoring, evaluation and reporting

- What methodology was put in place to track the implementation progress and success of the project, as well as the impact in reducing the risks originally identified?
- Did this process seek to account for the full range of potential costs and benefits or was the focus solely on addressing the original identified risk?
- Can you provide any data (quantitative or qualitative) demonstrating the outcomes/benefits of the project? Was the necessary data already being gathered through existing processes, or was it necessary to undertake new monitoring?
- Were the costs and benefits realised in line with those expected at the time the project was initiated?
- Have any longer term monitoring and evaluation processes been put in place to track effectiveness of the project over time? What is this showing?

Stakeholder engagement

- What level of stakeholder engagement outside your own organisation was required to scope and implement the project?
- How did the aims and interests of different groups vary? Where there were variations, what techniques or strategies were effective for mediating and resolving the issues?
- What made collaboration between these groups successful (or difficult)?
- Overall, do you feel collaboration with other stakeholders helped or hindered the project's success?

Success factors and lessons learnt

- What challenges did you face during implementation and is there anything you would have done differently in retrospect?
- What factors contributed to your success? Were there particular preconditions that allowed your project to go ahead?
- Are there any specific lessons learnt that you would like to share with anyone considering the implementation of a similar project elsewhere?

Additional questions for adaptive capacity/ partnership working projects

- What governance arrangements have been in place to drive forward and champion adaptation work? How effective have these been in supporting progress?
- How have you developed leadership support for action to adapt and what role has this played in supporting progress?
- What training have you put in place to further develop resources (skills and knowledge)? How many people have participated in this training and was any monitoring of competencies undertaken?
- Have you developed partnerships with other organisations (e.g. academia) to develop your evidence further?
- Have you undertaken vulnerability or risk assessments? What has been the impact of doing this?
- Has your project / activity influenced the design and delivery of other projects / activities in the City? If so, how?
- Do you actively seek to shape the plans, strategies and projects of your organisation / other organisations?
- Have you run public / stakeholder events on the impacts of climate change and adaptation? How many people have attended and how has it built momentum?
- Does part of your project involve seeking to convince decision makers? If so, would you say this has been effective?

Appendix D
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