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SUPPORTING DECISION –
MAKING FOR RESILIENT CITIES

Climate Change Adaptation and Resilience Policy

A Baseline Assessment for Greater Manchester

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List of Acronyms

Acronym	Full Title
AGMA	Association of Greater Manchester Authorities
ASC	Adaptation Sub-committee
CCA	Civil Contingencies Act
CCC	Committee on Climate Change
CCRA	Climate Change Risk Assessment
CCRU	Civil Contingencies and Resilience Unit
CNI	Critical National Infrastructure
EA	Environment Agency
EIA	Environmental Impact Assessment
EU	European Union
FRMP	Flood Risk Management Plan
FWMA	Flood and Water Management Act
GI	Green Infrastructure
GM	Greater Manchester
GMCA	Greater Manchester Combined Authority
GMS	The Greater Manchester Strategy
GMSF	Greater Manchester Spatial Framework
LEP	Local Enterprise Partnership
NPPF	National Planning Policy Framework
NPS	National Policy Statement
RFCC	Regional Flood and Coastal Committee (RFCC)
SEA	Strategic Environmental Assessment
SI	Statutory Instrument
SuDS	Sustainable Drainage Systems
SWMP	Surface Water Management Plan

TfGM	Transport for Greater Manchester
UK	United Kingdom
WFD	Water Framework Directive

Executive Summary

Background

Climate change is happening now with average temperatures are around 1°C higher than 100 years ago, and extreme events seem to be becoming more frequent and more intense. A robust policy framework is needed in order to support adaptation and to make Greater Manchester's (GM) people, infrastructure and built environment more resilient to the changing climate. The EcoCities Project (2009 – 2012) identified three themes for adapting GM to the changing climate and focussed on 'safeguarding our future prosperity', 'protecting the most vulnerable in our society', and 'building the resilience of our essential infrastructure' (Carter et al. 2015). This current report focuses on the latter of these themes and provides an overview of relevant policies and legislation at national and GM level that relate to climate change adaptation and resilience with a focus on infrastructure. The policy review covers three main areas including climate change and flood risk management, spatial planning and economic development, and civil contingencies and resilience.

Key Issues

The review shows that, at a national level, the UK is one of the front-runners in terms of climate change adaptation policy in Europe. Within a multi-level governance framework, GM has increasingly obtained greater powers from central government and aspires to be a world-leading digital and green city. GM also has stated goals of 'rapidly adapting to the changing climate'. GM is also a signatory to Mayors Adapt and is one of the Rockefeller Foundation's 100 Resilient Cities. Therefore, there are high-level commitments to ensuring that GM is well-adapted and resilient to climate change.

Planning for adaptation is relatively well-developed, particularly in the area of infrastructure development, but there are question marks over the implementation of policy initiatives and the ability to retrofit existing infrastructure. The funding mechanisms to support implementation are also opaque and, given that adaptation to climate change is not mandated for at local authority level, unlike countries such as Germany and Austria, there is little incentive for local authorities to take the lead on delivering adaptation projects.

Even so, climate change adaptation and resilience has a number of policy hooks at national and GM level which means that, with the right support, attention can and should turn to implementation of measures and the development of robust indicators to monitor progress.

1. Introduction

1.1. Aims

Public policy set by a government provides the framework within which societal stakeholders are compelled to act. This report provides a baseline assessment of current policy relating to climate change adaptation, climate resilience, and infrastructure, which specifically relates to Greater Manchester (GM). It is valuable for two main reasons:

- Adapting to climate change is a cross-sectoral and multi-scale activity that requires action at a range of governmental levels. Legislation also evolves over time, meaning that legitimate levers of action may be present in a number of legislative areas. An understanding of the wider policy landscape will therefore help to identify levers for action in different sectors, and at different scales, as well as potential policy gaps.
- By enabling the linking of legislation to different stakeholders, this baseline assessment will be a useful communication tool, which is relevant in the United Kingdom (UK) context where many responsibilities for infrastructure have been devolved to non-governmental actors such as utilities companies and transport operators.

This policy review aims to:

- provide an overview of the key pieces of legislation that apply to different stakeholders in GM in order to identify existing levers for action, and key gaps, to progress climate change adaptation and resilience of critical infrastructure;

The objectives of the policy review are to:

- understand the extent to which different types of legislation address climate change adaptation and resilience to critical infrastructure;
- identify particular legislation that GM's stakeholders potentially need to respond to; and,
- ascertain gaps in legislation relating to climate change adaptation and resilience, with particular reference to infrastructure.

1.2. Definitions

Infrastructure is defined differently at local and national levels. Infrastructure planning and critical infrastructure protection (CIP) are a national priority for the UK government. Thirteen sectors are regarded to be 'critical' at the national level: food, energy, water, communications, transport, health, emergency services, government, and finance (Cabinet Office 2010: 4 - 5), with chemicals, civil nuclear, defence and space as recent additions (Cabinet Office 2015). The UK's Climate Change Risk assessment (Dawson 2015) covers six infrastructure types: flood and coastal erosion, risk management infrastructure, water infrastructure, digital communications (ICT) infrastructure, transport, energy, and solid waste. GM's draft Spatial Framework (2015) addresses transport, utilities, and social infrastructure:

- Transport infrastructure – air (Manchester), rail, port (Salford) tram (metrolink), road, walking and cycling;
- Utilities infrastructure – gas, electricity, heat, digital connectivity, water and waste water;

- Social infrastructure – schools and education, health services, community facilities, recreation provision and green infrastructure.

1.3. Approach

1.3.1. Sources

Three themes were selected as being relevant to GM because they result from the division of responsibilities regarding climate change risk to critical infrastructure at national level. The themes are:

- Climate change adaptation, flood risk management, and green infrastructure
- Spatial planning & economic development
- Civil contingencies and resilience

Policy documents were reviewed to judge the extent they would impact on climate change adaptation and/or climate resilience in terms of providing strategic direction or a framework for action. The content review focussed on:

- references made to acknowledge and/or address the risk of current weather extremes, with a focus on infrastructure and the built environment
- references made to acknowledge and/or address to future issues with a changing climate, with a focus on infrastructure and the built environment.
- The existence of statutory drivers and/or policy hooks for climate change adaptation and resilience
- Links to related policies.

A summarised form of the content review for each policy is given in Annex 1. Given the focus of the RESIN GM Case Study on infrastructure, the main parameter of this policy review is legislation that impacts on infrastructure in Greater Manchester. The review includes documents published to April 2017.

1.3.2. The UK legislative and policy framework

The review has covered different types of legislation and policy at both the UK national level and local government level, in this case the Greater Manchester Combined Authority (GMCA).

At national level, primary legislation takes the form of Acts of Parliament. These may be written at a very general level and, consequently, confer power upon ministers to outline Statutory Instruments (SIs), or secondary legislation, which provide more detailed orders, rules and regulations. Sometimes, an Act or SI will instruct a governmental department to produce detailed guidance on a subject area, and this guidance is therefore statutory.

Some policy papers may become legislation, often in a modified form, but not always. White papers, for example, act as a consultation document on a government's proposed vision. A number of other government sponsored documents were also included in the review. For example, progress reports and updates on the implementation of policy were assessed to ascertain the extent to which action on climate change adaptation and climate resilience was occurring.

Local authorities are responsible for delivering services such as spatial planning, education and waste management. Notwithstanding recent legislation, which has devolved more powers to local government (Cities and Local Government Act 2016; Section 2.1), local authorities typically enact national legislation either directly or with some discretion over how a statutory law is put into practice.

1.4. Caveats

This report is based on a desk based review only. Consequently, it is not known the extent to whether a policy is directly affecting a stakeholder's day-to-day actions.

Additionally, policy can also change quickly, particularly when there is flux in the political situation. For example, there is much uncertainty regarding the UK's recent referendum result to leave the European Union (EU). This does not mean that climate change will fall off the policy agenda since the UK's commitment to tackling climate change is enshrined in national legislation through the Climate Change Act (2008) (Committee on Climate Change 2016: 11). The Climate Change Act (2008) tackles climate change adaptation; however, there may be an impact on funding for adaptation measures, which often comes from the EU. It should be noted that major pieces of EU legislation, the Water Framework Directive, the Floods Directive, and the EIA Directive have already been legislated for in UK law.

2. PRESENTATION OF RESULTS

2.1. Governance

Before discussing the baseline assessment results in greater detail, background information on the main mechanisms in local government, particularly city devolution deals, and responsibilities for the management of infrastructure are outlined.

2.1.1. Greater Manchester

The governance situation in Greater Manchester is undergoing much organisational change as a result of devolution. The ten local authorities that comprise GM have, for four decades, voluntarily worked together on significant, 'larger-than-local' issues such as flooding, ecology, transport and waste as the Association of Greater Manchester Authorities (AGMA). By 2008, a Manchester 'Multi-Area Agreement' was signed between AGMA and central government (AGMA and Manchester Enterprises 2008), which aimed to acquire more autonomy for GM. Building on this initiative, Manchester was chosen as a pilot city-region (along with Leeds) in 2009, further cementing the collaboration between GM's districts. Eventually, a Combined Authority has become the preferred conurbation scale governance model, with the GMCA statutorily recognised in 2011 to focus on economic development, regeneration and transport (Rees & Harding 2010). To date, the governance model is made up of elected members as well as representatives from the private sector, particularly through the GM Local Enterprise Partnership (LEP) which is an economic growth focused partnership between private sector organisations, the education sector and local authorities.

The success of the conurbation level experiment has been enshrined in further devolution powers, including the election of Andy Burnham as GM's mayor who has pledged to make GM 'a world-leading Digital City and Green City' (<http://www.burnhamformayor.co.uk/ourmanifesto>). Meanwhile, further devolution through the Cities and Local Government Devolution Act (2016) is providing some local authorities with more control for certain budgets. Since the Act is enabling, there is flexibility over the terms agreed by individual local authorities/combined authorities and therefore the text in the document did not specify the 'deals' that each local authority/combined authority will make. In addition, there is future flexibility for a local authority/combined authority to request more powers. Whilst climate change and resilience are not mentioned specifically, changing governance arrangements may impact on, and/or provide an opportunity for, progress in this area particularly where connections between climate change and headline agendas such as health and economic development can be made.

2.1.2. Responsibilities for infrastructure

The major transport and utilities companies are largely privatised in the UK, although centrally regulated. For example, the energy suppliers in the UK are regulated by the Office of Gas and Electricity Markets (OFGEM), with the remit of protecting 'the interests of existing and future electricity and gas consumers' in terms of price controls and ensuring future supply (<https://www.ofgem.gov.uk/about-us/who-we-are>). Table 1 gives an overview of the roles and responsibilities for the major infrastructure sectors in the UK.

Sector	Policy
Roads	Strategic roads are maintained and developed through the national government by the Highways Agency. Local roads are the responsibility of local authorities.
Rail	Physical infrastructure is maintained and developed by Network Rail (part Government funded)
Aviation	The aviation industry is privatised. The government's role is to facilitate competition.
Energy	The energy sector is privatised. Government provides a regulatory framework that aims to minimise consumer costs and to meet renewable energy targets.
ICT	The communication sector is privatised. Government provides a regulatory framework that aims for affordability and coverage for the consumer.
Water	The water sector is privatised. Government provides a regulatory framework to ensure that water is at a safe and acceptable standard, that costs are minimised for the consumer, and that future supply is guaranteed.
Waste	Government ensures that current waste infrastructure, provided by private companies and local authorities, is acceptable.

Table 1: Roles and responsibilities for government with regard to infrastructure. Adapted from (Rhodes, 2016: 7).

2.2. General Overview

The policy review was developed as a timeline in order to understand how legislation has developed in the three identified areas. The analysis is presented chronologically in Figure 1. The earliest policy document was 1976 (The Energy Act). However, the majority of the documents relate to the period between 2005 and 2015.

A large amount of legislation relating to climate change adaptation, such as the Climate Change Act (2008), was passed under a Labour government in the period before 2010 and, significantly, just as a major economic recession began. Since 2010, however, the legislative impetus has been a deregulatory one and there have been less initiatives on climate change adaptation. At national level, legislation has been focussed on infrastructure, which has become strongly tied

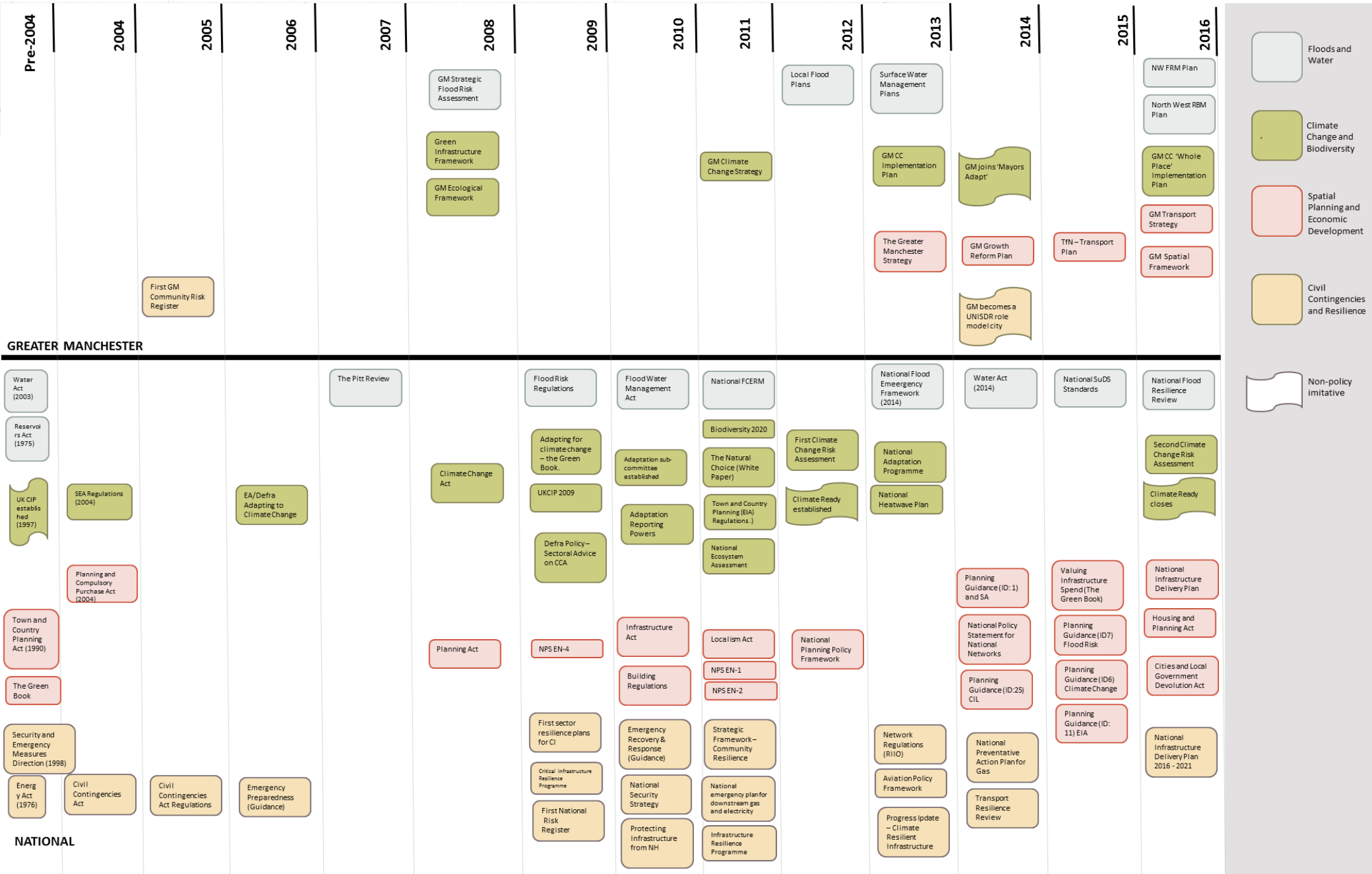


Figure 1: Timeline of climate change and resilience related policies. Source: Authors

to an economic growth agenda through the Infrastructure Act (2011), the Growth and Infrastructure Act (2013), and a number of national planning statements (NPSs) that relate to nationally significant infrastructure.

Much of the GM legislation has emerged since the formalising of the governance arrangements, as discussed above, and is beginning to express itself in the development of major frameworks and strategies, such as the Greater Manchester Strategy (GMS) (2013) and the Greater Manchester Spatial Framework (GMSF) (2016).

The following sections examine the policy initiatives thematically, particularly to identify the roles and responsibilities for different organisations and the extent to which climate change adaptation is addressed. The climate change resilience and adaptation issues in certain policies are outlined in detail in Annex A.

2.3. Climate Change, Flooding, and Water

2.3.1. UK Government Policy on Climate Change

Oft regarded as a ‘laggard’ behind European compatriot governments in terms of environmental policy, the UK recognised the importance of climate change in the late 1980s (Benson and Lorenzoni 2014). Consequently, the UK is one of the frontrunner countries in terms of climate change policy (Bowen and Rydge 2011: 33 - 34). The political impetus resulted in the UK passing the world’s first legally binding, long-term framework to address climate change through the Climate Change Act (2008). Part Four of the Act deals with adaptation and requires the UK Government to produce quinquennial Climate Change Risk Assessments (CCRA). To date, there have been two CCRA’s (2012; 2017). Following the CCRA (2012), a National Adaptation Programme (2013) was developed to provide a risk-based national policy response across sectors; and infrastructure is one of the identified sectors. Fifteen NAP objectives relate to GM’s infrastructure including an action to make best use of exemplars with respect to (iconic) climate change resilient infrastructure management, utilising experience from projects and programmes already embedding adaptation.¹

Moreover, the Climate Change Act (2008) established an impartial Committee on Climate Change (CCC) with a specific sub-committee - the ‘Adaptation Sub-Committee’ (ASC) - to support the CCRA, monitor progress and scrutinise further legislation on climate change adaptation. The Department for the Environment, Food and Rural Affairs (Defra) was given further powers to oblige the main infrastructure organisations to assess their climate change risk and to report on how that risk will be addressed (“adaptation reporting powers”). The next section thus turns to the specifics of adaptation and resilience with regard to infrastructure.

Climate Resilient Infrastructure

Infrastructure policy is mainly driven by concerns over the economic competitiveness of the UK, as evidenced through Infrastructure Acts (2011; 2015) and the Growth and Infrastructure Act (2013). However, the Climate Change Act (2008), environmental directives from the EU, and projected

¹ Analysis by Matt Ellis, Environment Agency.

population growth have also necessitated a renewed focus on the provision of infrastructure, particular relating to the land use requirements and necessary planning permissions (Coelho et al., 2014).

Planning for major new infrastructure development is tightly controlled by central government and involves attracting a large proportion of private investment. Initially, Infrastructure UK (IUK) was established in 2010 to oversee major infrastructure projects that use public sector capital. In 2016, IUK was merged with the Major Projects Authority, which oversaw the largest projects, to form the Infrastructure and Projects Authority, under the auspices of the Cabinet Office.

The long-term impacts from climate change, particularly in the risk they pose to investments and economic concerns, are being embedded in key UK infrastructure policy-relevant documents. In 2009, Defra established the 'Adapting the National Infrastructure' programme which resulted in a policy paper that contained the vision for 'an infrastructure network that is resilient to today's natural hazards and prepared for the future changing climate' (HM Government 2011: 1). The report underscores the view that government provides strategic direction and guidance on this; however, action 'should be undertaken by investors, owners, operators, insurers, professional sectors' (HM Government 2011: 33). Although the insights of the report relate to national infrastructure, the suggested strategic approach 'can be replicated at the sub-regional and local level by local authorities and the...Local Enterprise Partnerships (LEPs)' (HM Government 2011: 39).

Allied to this work, was the establishment of the Infrastructure Operators Adaptation Forum group, overseen by the EA's Climate Ready service, to share knowledge amongst infrastructure operators. Whilst Climate Ready ceased to function in March 2016, the work of the forum continues.

It seems clear that adaptation is relatively well developed in the area of infrastructure as noted in the CCRA 2017; nevertheless, some caution is attached to this observation:

there is evidence that significant adaptation steps to manage climate change risks have been implemented, or are underway, across most infrastructure sectors; however, this should not lead to complacency as the longer term prognosis beyond the 2030s is that projected changes in climate are *likely to outpace* current adaptation plans. (Dawson 2016: 69, added emphasis).

Additionally, a number of policy documents and the academic literature note that there is a lack of understanding on the interdependencies between sectors (HM Government 2011; Bollinger et al. 2014; Dawson 2016). This is exacerbated by the tendency for the regulation and development of infrastructures in silos.

2.3.2. Greater Manchester policy on climate change

Greater Manchester has made a series of high profile commitments to tackling climate change, and adapting to the consequences. This has culminated in the signing to Mayor's Adapt, a global initiative which, by membership, requires cities to integrate climate change adaptation into its plans, to report on progress and to share learning with cities across the world.

Mayors Adapt builds on the GM Climate Change Strategy (2013) and the GM Climate Change Strategy Implementation Plan (2015). Although carbon emissions reduction is examined in most detail, adaptation emerges as a strong theme. For example, the implementation plan notes a need to invest and deliver schemes in transport; energy (heat and power), building retrofit, and flood risk management, to enhance resilience. (GMCA/AGMA 2015: 3). A refresh of the Implementation Plan,

entitled the Climate Change Low Emissions Strategy (CCLES), was undertaken in 2016 (Greater Manchester Low Carbon Hub, 2016). Again, there is a target, by 2020, to 'have a clear understanding of the main climate risks faced by Greater Manchester and [to] have developed a stable, integrated working arrangement across key actors' (Greater Manchester Low Carbon Hub, 2016: 15). Specific actions on this theme include understanding the risk to GM's transport infrastructure from extreme weather events, which is discussed in greater detail in Section 2.4.3.

2.3.3. UK policy on flood risk management (FRM)

Much UK national policy on flood risk management has been shaped by European policy; namely, the Floods Directive (2007) which was translated into national legislation via the Flood Risk Regulations (2009). The directive required the publication of risk maps related to different types of flooding, the publication of local flood risk assessments and greater communication of the risks along with other non-structural flood risk measures.

Another driving force of flooding legislation is an extreme weather event which provides a 'window of opportunity' for policy change, although it is not always clear whether such opportunities are implemented (Johnson et al. 2005). The Pitt Review, following severe flooding in 2007, made recommendations that have mostly had an influence on policy including the uptake of property level resilience measures and recommendations to identify the flood risk to national critical infrastructure, including the protection of CNI to a standard of at least a 1 in 200 flood event. Floods in Winter 2013/14 – which almost reached the city of London – similarly prompted a high profile review into the resilience of the UK transport network, which identified a series of measures that needed to be undertaken across road, rail and air (Brown 2014). Further flooding in 2015/16, because of Storms Desmond, Eva and Frank, significantly affected the north of England with disruption to infrastructure. Following this, the government commissioned a national flood resilience review (HM Government 2016 [known as the Letwin Review]). Importantly, the report identified key locally important infrastructure sites and made recommendations for their protection with temporary flood barriers. However, the modelled flood outlines mainly focussed on the next ten years rather than taking account of long-term climate change.

The governance of flood risk management in the UK is commonly acknowledged as a fragmented one with responsibility split depending on the type of flooding (White et al. 2015). The Flood and Water Management Act (FWMA) (2010) sets out the main roles and responsibilities:

- the Environment Agency oversees coastal and river flooding;
- local authorities (lead local flood authorities) oversee surface water flooding, groundwater, and ordinary watercourses as well as assuming responsibility for preparing a local flood risk management strategy;
- utility companies are responsible for drains.

Regional Flood and Coastal Committees (RFCC) play a key role in the delivery of flood risk management (except for that covered by utilities provider), particularly in the allocation of flood defence spending. Lead local flood authorities have representation on the RFCC, with the purpose of coordinating activities at a higher spatial level.

The Letwin review, discussed above, also focuses on the economic development agenda and how this is linked to resilience. Sheffield, a core city in the north of England, has been selected as a pilot region

for the innovative exploration of increasing city flood resilience by tying into local regeneration initiatives. National Government is therefore encouraging other core cities, such as GM, to follow suit and learn from Sheffield in order to 'own and lead this resilient (re)development' (HM Government, 2016, p. 25).

There are strong synergies between flood and coastal risk management policies and climate change adaptation, with the former domain taking account of climate change and sea level rise for two decades in a number of policies and legislation (Dawson 2016, p. 30). There is flexibility to respond to new data when it becomes available: the Environment Agency, for example, has recently modified the allowances for climate change and, in the case of critically significant infrastructure, applying a risk averse strategy utilising the highest scenarios (Environment Agency 2016). Even so, flood risk management is predominantly concerned with preparing for the current risk of flooding.

In terms of solutions to manage floods, Sustainable Drainage Systems (SuDS) are encouraged through the national planning system. SuDS are designed to mimic natural drainage flows. Whilst it is easier and most cost-effective to construct SuDS on new developments with abundant land, they are of particular use in retrofitting to cope with the lack of capacity in existing drainage in cities and increased urbanisation. Planning Guidance ID (7), concerning Flood and Coastal Risk, maintains that new developments in flood risk areas must consider SuDS as a priority, whilst major developments must design in SuDS unless deemed inappropriate. The main responsibility for SuDS lies with local planning authorities, which runs counter to the FWMA's insistence on separate SuDS Approval Bodies. There is uncertainty over who pays for the installation of SuDS (the local authority, the utilities company or the developer), who maintains SuDS and, because of their high land take, SuDS are not particularly attractive to property developers. The situation is exacerbated because of the large funding cuts to local planning authorities and lead local flood authorities.

2.3.4. GM flood risk management policy

As a consequence of transposing the EU directives, flood and water management in the UK is undertaken at catchment scale. The Environment Agency has published a North West river basin district Flood Risk Management Plan (FRMP), with a section on GM's flood risk. FRMPs set out how risk management authorities will work with communities to manage flood and coastal risk over the period 2015-2021. Climate change adaptation features strongly in the FRMPs; for example, objective 1 (of 12) in the North West is to 'support climate change adaptation by making space for water, both inland and at the coast' (Environment Agency 2016b, p. 69). The plan also notes the problem of aging infrastructure such as sewers and drains in the north-west of England (Environment Agency 2016b, pp. 80 – 90). Nature based flood risk management options are preferred where possible.

At the local level, each of the ten GM districts has a local flood risk management plan. Surface water management, however, is undertaken cooperatively across the boroughs; with a surface water management plan covering Manchester, Salford, and Trafford, for example (JBA Consulting 2012). All of these account for climate change, in line with the Environment Agency guidelines detailed above. There are delivery groups that operate across GM level which encourage partnership working and the sharing of knowledge, such as GM's Flood and Water Management Board and the GM Flood Risk Officers Group.

GM advocates the use of SuDS through the analysis contained with the Surface Water Management Plan (SWMP) 2012. However, responsibility lies with the local planning authorities. Manchester City

Council, for example, encourages SuDS use through their 'Guide to Development in Manchester - Supplementary Planning Document and Planning Guidance (SPD)' (2007) in order to address the Water Management and Weather Resilience theme, which is one of seven environmental standards that the Council seeks to uphold in new developments. Strengthening such local level planning requirements may be one means of upholding the climate change adaptation and resilience agenda where national legislation is vague or lacking.

2.3.5. Water supply and treatment

The impact of climate change on water supply and sewerage services in the UK will be significant, particularly in terms of drought. A report for the Committee on Climate Change (HR Wallingford 2015) looked at the supply demand balance for water at regional scale over a range of time periods, accounting for both climate and population change. It is projected that there will be an imbalance of supply and demand for water, given both climate and population change, in the absence of any adaptation measures (such as restricting abstraction measures). Whilst the risk of drought is potentially acute in the south and east of England, a small number of catchments in the north-west of England will also be affected in the future.

As with flood risk management, water supply and sewerage is managed at the catchment scale in river basins because of the European Water Framework Directive (WFD) (2003). The industry is wholly privatised in the UK and the regulator is OFWAT. However, there is strong legislative management that compels the water industry to maintain adequate supply for current and future generations. This means that, unlike other sectors, the water industry has long planning horizons, the Water Industry Act (1991; amended in 2003) requires each water company to produce, every five years, a water resource management plan that sets out how the company will provide a secure supply of water for a twenty-five year period with an accompanying drought plan.

The more recent Water Act (2014) further underscores the protection of future water resources and outlines changes to the abstraction of water, managing consumer demand, and adapting water supply infrastructure. OFWAT is statutorily obliged to 'further the resilience objective' (section 22). This is 'long-term' and must take account of environmental pressures (including climate change), population growth and consumer demand. The Water Resource Management Plan, following the passing of the Water Act (2014), can be produced with certain assumptions around resilience and the security of supplies in drought conditions if the Secretary of State compels a water company to do so.

The UK's water industry can therefore be considered highly aware of climate change adaptation themes due to the long planning timescales and the legislative impulse to consider resilience and protecting supplies for future generations.

2.3.6. National policy on the natural environment and green infrastructure

In terms of the natural environment, a white paper was published by Defra in 2011 (the 'natural environment white paper'). The paper contained 92 commitments and, until 2014, Defra reported on progress on the implementation of the white paper with around three-quarters of commitments fulfilled by the time of the last report (Defra 2014). The white paper also established the Natural Capital Committee as an independent advisory committee whose remit includes forests, rivers, land and ocean. The Natural Capital Committee publish annual 'State of The Natural Capital' reports and argue

strongly for a 25-year plan for natural capital. Defra have, since the white paper, been developing a 25 year environment plan (25YEP) that should be published during 2017. As part of this, Defra have identified a number of 'Pioneer' projects that will test aspects of the 25YEP. GM has been selected as one of four pioneer areas with a project lasting for around three years.

The white paper also led to the establishment of a Green Infrastructure Network that comprises of public and private sector stakeholders in order to support the implementation of green infrastructure. Green infrastructure (GI) also provides vital resilience functions, and an argument can be made that it should be treated as an infrastructure type in itself; indeed, where GI performs flood risk functions, it seems reasonable to take a similar approach to the UK Climate Change Risk Assessment (Dawson 2016), which considered flood risk infrastructure as 'at risk' from climate change. This should be further extended to cover GI's contribution to adapting to heat stress. For example, severe droughts may reduce GI's evapotranspiration functions and, consequently, its ability to cool and delay surface water runoff. GI may cut across some of the core critical infrastructure systems: a transport system may comprise of SuDS that mitigates flood risk. This is recognised, to an extent, in the natural environment white paper where a theme is 'helping the natural environment to adapt to climate change' (Defra 2011: p. 10 [para 1.15]).

2.3.7. GM policies on the natural environment and green infrastructure

At GM level, there is a GI framework that was adopted in 2011. GM's early focus on GI has been harnessed by significant local level research evidence. The robustness of the evidence base has meant that the GI framework is considered one of the delivery mechanisms of the GMS and GI is integrated across a number of other relevant strategies and documents. For example, the draft GM Spatial Framework notes that: 'Rethinking and restructuring the existing green space network as an 'ecosystem service' to improve its performance, and greening the built environment, would enable the conurbation to address a number of environmental and social imperatives' (GMCA/AGMA 2015).

The national natural environment white paper also introduced the concept of 'local nature partnerships' (LNPs) to address stakeholder concerns that Local Enterprise Partnerships (LEPs), established as a partnership between businesses and local government in order to drive economic growth, lacked any environmental remit, even though sustainable development is at the heart of national and local strategies and plans. GM's LNP is delivered through the 'Natural Capital Group', which works on a number of aspects of GM's environment, including overseeing activity on green infrastructure. This group will oversee the work of GM's Pioneer project for Defra.

2.4. Spatial Planning and Economic Development Policy

2.4.1. UK planning policy

Climate change adaptation has been recognised in UK planning policy for almost a decade. The Planning Act of 2008 (Section 182), for example, amended Section 19 of the Planning and Compulsory Purchase Act (2004) by inserting a clause to ensure that local development plan documents 'must (taken as a whole) include policies designed to secure that the development and use of land in the local planning authority's area contribute to the mitigation of, and adaptation to, climate change.'

The main policy planning document in the UK is the National Planning Policy Framework (NPPF). Climate change mitigation and adaptation are stated as a strategic priority under the NPPF, and all local plans should set out strategic policies to demonstrate delivery (Section 156: 37 – 38). The NPPF carries over earlier guidance that requires local plans to be supported by strategic flood risk assessments, and for the sequential and exception tests to apply to new developments (Section 100: 23). Green infrastructure is also represented in the NPPF; new developments should be planned to avoid increasing vulnerability to climate change impacts and ‘care should be taken to ensure that risks can be managed through suitable adaptation measures, including through the planning of green infrastructure’ (Section 99: 23). Local authorities are also encouraged to strategically plan for green infrastructure (Section 114: 27). There is, therefore, a strong steer for planners to address climate change through design and development, but this is not binding.

A suite of Planning Practice Guidance documents accompany the NPPF including one on climate change that provides a general guide to the type of adaptation actions that can be addressed (CLG 2015). This includes:

- considering future climate risks when allocating development sites to ensure risks are understood over the development’s lifetime;
- considering the impact of and promoting design responses to flood risk and coastal change for the lifetime of the development;
- considering availability of water and water infrastructure for the lifetime of the development and design responses to promote water efficiency and protect water quality;
- promoting adaptation approaches in local design policies;
- and encouraging partnership working to develop local approaches.

Building regulations are an important feature of development control in the UK planning system as the statutory instrument; however, none of the building regulations explicitly cover resilience even though there are persuasive arguments to address resilience to flooding at the property level (Garvin n.d.). The lack of resilience/adaptation measures in the building regulations is a significant gap. It is possible that local advice, as suggested in the Planning Guidance (ID6) on Climate Change, ‘could reflect adaptation approaches in design policies for developments and the public realm’.

Environmental Impact Assessment (EIA) is also legislated for in the UK planning system as prompted by the EU Environmental Impact Assessment Directive (2011). The Town and Country Planning (EIA) Regulations 2011 requires an environmental assessment for all new developments. This must include appraisal of all the potential environmental impacts of projects, including ‘climatic factors’. In addition, the Strategic Environmental Assessment (SEA) Directive, adopted by the EU in 2001, requires an assessment of plans and programmes likely to have significant environmental effects against a defined set of environmental criteria. This became part of UK legislation through the Environmental Assessment of Plans and Programmes Regulations 2004 (Strategic Environmental Assessment Regulations). Sustainability Appraisals have evolved in order to meet the UK’s SEA requirements. Both ‘climatic factors’ and ‘health’ are part of the SEA criteria when assessing local plans and programmes. Consequently, EIA and SEA (through sustainability appraisals), are potential tools for testing the integration of mitigation and adaptation measures in new developments (NPPF 2012: para 4). Both are covered in separate planning guidance documents relating to the NPPF.

Policies that may have a bearing on climate change adaptation include the recently passed Housing and Planning Act (2016). Of note is a requirement that a register of brownfield land that is suitable for housing development is to be maintained by local authorities; GM was one of the initial pilot areas for developing a brownfield land register in 2016. Brownfield land in GM is mainly in the urban heat island and, it could be argued, that they could potentially perform vital climate resilience functions (including urban cooling and flood risk management) if turned into open areas (Polyakova 2011).

Planning for infrastructure

Section 5(9) of the Planning Act (2008) required the Secretary of State to ensure that mitigating and adapting to climate change is accounted for when planning national infrastructure projects. To this end, a series of detailed National Policy Statements (NPS), which have been developed for different infrastructure types, contain distinct sections on adaptation. This underscores the integration of climate change adaptation into allied infrastructure policies, as noted in Section 2.3.1. Each NPS recommends that, through an environmental assessment, the developer must take the projected impacts of climate change adaptation into account for the longevity of the infrastructure life in terms of location, design, build, and operation. Furthermore, flexibility and adaptability are encouraged to allow resilience measures that may not be required in the present, to be incorporated in the future.

2.4.2. GM planning and economic development policy

Produced by the Greater Manchester Combined Authority (GMCA), the Greater Manchester Strategy (GMS) is the overarching framework that sets out GM's plans to drive economic growth and prosperity. The vision is for a self-sustaining city region that, whilst delivering economic growth, also promotes a good quality of life, a low carbon economy and a commitment to sustainable development alongside an outstanding natural environment. The need to adapt to a changing climate and the impact of extreme weather events is explicit along with an aspiration to invest in green and blue infrastructure for the climate resilience services it provides (GMCA 2013: 47). The GMS has led to a suite of documents that underpin and support its expression including, in terms of climate change adaptation, the GM Spatial Strategy and the GM Green Infrastructure Framework (discussed above) are the most important.

The GM Spatial Strategy, currently in draft form, is the joint statutory spatial plan for GM to deliver land for new housing, jobs, and infrastructure up to 2035. The GMSF's scope outlines a commitment to climate change adaptation since: *'climate change will be part of the overall spatial strategy, and a consistent theme through the GMSF, with a broad approach to maximising economic opportunities whilst reducing emissions and enhancing resilience/adaptation'* (GMCA/AGMA 2015: 2). Infrastructure and environment form a distinct component of the GMSF, and there are commitments to respect the environmental capacity of GM in order to deliver sustainable growth, such as influencing design and location in order to take account of climate resilience. GI is embedded in the GMSF as a means of providing resilience in the context of a changing climate (GMCA/AGMA 2015: 19).

2.4.3. GM Transport

The varieties of transport in GM (road, rail, Metrolink, bus, cycling, walking) are coordinated by Transport for Greater Manchester (TfGM). TfGM owns some structures and is responsible for investment across the ten boroughs. TfGM have produced a strategy document that outlines the vision

for GM's transport up to 2040 (TfGM 2017). Resilience is recognised within the strategy as a distinct theme and climate change is identified as a significant challenge, although specific impacts are not identified. In terms of resilience, TfGM has an ambition 'To bring the transport network into a good state of repair, maintain it in that state and ensure that it is able to withstand unexpected events, exceptional demand and severe weather conditions (TfGM 2017: 12). As part of that ambition, TfGM have developed a policy that ensure that the organisation '...will work with partners to maintain the transport system to a good standard, adapt it and improve its resilience to the effects of climate change (TfGM 2017: 12).

Transport is included as a priority theme within the CCLES delivery plan (Greater Manchester Low Carbon Hub 2016 p.10). A series of CCLES actions relate to transport, and are listed below:

A12: Identify key risks to transport infrastructure posed by increased incidence of flooding and heat as part of Transport Strategy and Planning.

A13: Integrate requirements for shelter from extreme weather and heat into building design and transport systems as part of a sustainable design guide.

A14: Strengthen traveller notification systems to ensure that they respond to weather risks more effectively, including air pollution risks.

These actions are to be led by TfGM. Resources are required from TfGM to support the achievement of these actions, in addition to resources from RESIN (for A12) and EU funds (for A13).

2.5. Civil Contingencies and Resilience

2.5.1. National level civil contingencies and resilience

General resilience to civil emergencies is covered by a robust and extensive policy framework, particularly under the terms of the Civil Contingencies Act (CCA) (2004) which looks at all hazards. The CCA (2004) was developed in response to a series of national emergencies such as Foot and Mouth disease and terrorism. The CCA provides for actions at both a national and local/regional level in terms of planning for, and responding to, potential emergencies. In terms of infrastructure, earlier Acts require guaranteed supplies (such as the Energy Act 1976; the Security and Emergency Measures Direction), and the CCA is invoked when all other available powers have been exhausted. National government assumes overall control in the case of an emergency.

There are a range of SIs associated with the CCA including the Civil Contingency Act 2004 (Contingency Planning) Regulations 2005, and guidance on Emergency Preparedness and Emergency Response and Recovery. Together, these set out a detailed framework for emergency planning and response. However, the focus is on a near-term emergency rather than future climate change. Nevertheless, the CCA covers extreme weather as a feature of ongoing climate change.

In 2008, the UK government published a National Security Strategy (Cabinet Office 2008), which requires central government to undertake an annual National Risk Assessment which, although confidential, is published in summary as the National Risk Register (Cabinet Office 2015). The risk assessment process captures the range of emergencies that might have a major impact on all, or

significant parts of, the UK. The latest risk register highlighted particular issues for critical infrastructure; the risk of complete failure of the electricity system is thought to be highly significant although very unlikely. Flooding is one of the highest national risks with energy and transport identified as sectors that are particularly vulnerable to extreme weather events. However, the National Risk Assessment takes a short-term time horizon of five years and considers risks that have a 1 in 20, 000 or greater change of happening, thus:

longer-term vulnerabilities or broader issues that have the potential to negatively impact on society, but which are not confined to single events (for example, climate change or organised crime), are not included and do not feature within the risk matrices. Instead, the effects of these are considered as part of the assessment of existing risks (Cabinet Office, 2015, p. 17).

This could highlight a mismatch in timescales between climate change and contemporary issues; however, climate change is intensifying current extreme weather events (Pall et al. 2011; Met Office/Centre for Ecology and Hydrology, 2014). Climate change adaptation therefore spans a number of time horizons and, consequently, there are mechanisms in place to recognise the effects of climate change as part of a broader risk profile, albeit not explicitly.

There are sector specific plans for emergencies, such as Sector Resilience Plans, that are updated yearly but remain classified. These emerged following a recommendation of the Pitt Review (2008) into extreme flooding. A summary document notes the risks for each sector and the plans in place to deal with emergencies (Cabinet Office 2016). In addition, a Strategic Framework and Policy Statement on Protecting Infrastructures from Natural Hazards (Cabinet Office 2010) established a cross-sector programme to improve the resilience of critical infrastructure and essential services to disruption from natural hazards. In line with national government policy, the reducing the vulnerability of infrastructure is to be delivered through three main themes: that it is consistent, proportionate (in terms of costs and benefits), and risk based. Again, the lack of knowledge and strategic direction in terms of interdependencies is noted: 'the framework is patchy and inconsistent. Much of what is presently being done is the product of ad hoc reactions to specific events or particular administrative processes' (Cabinet Office 2010: 6).

In 2011, the UK government established an Infrastructure Resilience Programme and published a guidance document that relates to infrastructure and extreme weather events: Keeping the Country Running: Natural Hazards and Resilience (Cabinet Office 2011). This document did not aim to suggest additional regulation or standard-setting, but, in line with the policy of empowering infrastructure operators to act, to share best practice and advice to enable owners and operators of the UK's infrastructure to improve resilience of infrastructure. There is a heavy focus on flooding, including the recommendation to protect critical infrastructure to a 1 in 200 year flood event (in line with the Pitt Review recommendations), but climate change is not considered.

2.5.2. GM civil contingencies and resilience

GM has a dedicated Civil Contingencies and Resilience Unit (CCRU), established to meet the requirements of the Civil Contingencies Act (2004). CCRU works with a range of agencies across the conurbation with a near term focus on the identification of threats and risks in order to ensure that GM is prepared for, and can respond to and recover from emergencies. An allied Greater Manchester Resilience Forum (GMRf) is made up of a range of agencies from across the conurbation that have a responsibility for emergency planning. The GMRf maintains the GM's Community Risk Register, which is updated on a yearly basis, as an assessment of emergency risks that are likely to affect the

local area. The Community Risk Register also suggests actions and plans to respond to a range of emergencies including the impact of extreme weather events (storms, droughts, floods, and heatwaves). Identified shocks for GM, with significant consequences, include both pluvial and fluvial flooding, which are considered one of GM's highest risks. In addition, the Community Risk Register for 2015 identifies that over half of the significant reservoirs in England are located in GM although the risk of failure is low (Greater Manchester Resilience Forum, 2015, p. 10).

In 2016, Greater Manchester joined the Rockefeller Foundation's 100 Resilient Cities programme, which takes account of a broad range of challenges (physical, social and economic) that cities should address in order to become more resilient. The programme suggests that a resilient city is one that not only addresses major shocks, such as an extreme weather event, but also the underlying stresses that create further vulnerabilities which one could consider climate change to be.

As part of the 100 Resilient Cities programme, GM's CCRU will produce a GM resilience strategy within three years. Ideally, such a strategy will be integrated and embedded within other GM strategies in order to ensure implementation. Such an integrated approach should, in principle, place GM on a strong footing to deliver on objectives relating to long term climate change adaptation planning and short-term climate resilience activities in relation to infrastructure.

2.6. Other Issues

2.6.1. Appraisal

An important aspect of integrating climate change adaptation into infrastructure is the ability to price adaptation into the planning for projects, and appraise different options for cost-effectiveness.

Public sector organisations are advised on the appraisal of project, prior to funds being committed, in the Green Book (HM Treasury, 2003). The Green Book looks at projects on an individual basis (rather than taking account of the benefit for infrastructure systems), and may be accused of taking a narrow economic view (Raikes 2015). Notable supplements to the Green Book include the Orange Book which looks specifically at the management of risk which outlines the assessment of risk based on an analysis of likelihood and consequences via a risk matrix (HM Treasury, 2004: 19 – 21). Further supplementary guidance (HM Treasury 2009) considers accounting for climate change. In addition, further supplementary guidance is dedicated to appraising resilience and interdependencies in infrastructure spending, and provides useful tools and cautions on the use of historic data:

to infer probabilities and risks over the long time horizons relevant for infrastructure investments; for example, some of the risks related to climate change, such as more extreme weather events, reflect the potential occurrence of events that have not been frequent in recent years. (HM Treasury 2015: 26).

A good example of an infrastructure regulator providing economic incentives for resilience and adaptation can be seen in OFGEM's price control review process known as Revenue = Incentives+Innovation+Outputs (RIIO) (Dawson 2016: 108). Allied to this, OFGEM provides an Environmental Discretionary Reward (EDR) scheme that incentivises to implement low carbon energy and high standards of environmental management; a focus on network reliability thus includes the

scope for climate resilient options. Therefore, the establishment of the RIIO model allows operators to cost in specific activities for resilience.

3. Analysis

The analysis of policy included in this review points to a number of main themes that consist of general observations about climate change and infrastructure with GM specific points.

3.1. General observations

- There is a well-developed framework for work on climate change adaptation, particularly regarding infrastructure. At national level, there is not only well-developed strategic direction on climate change adaptation policy, particularly regarding its integration within spatial planning, but a number of mechanisms are also in place to monitor and appraise progress. The flexibility to respond to changing circumstances, new data, and different types of climate change risks as they emerge is also encouraged for the planning of major national infrastructure projects.
- There are split responsibilities for infrastructure between national and local levels of government, and between the public and private sector. Further work should assess the synergies and linkages between different stakeholders and, in particular, how the policy landscape can join up to encourage action on climate change. This is particularly relevant with regard to infrastructure interdependencies.
- There is strong direction through the NPSs for new infrastructure developments to be climate proof for their lifecycle. However, such a legislative lever does not apply to the retrofitting of existing critical infrastructure, locally significant infrastructure, or for non-critical infrastructure such as the built environment where taking account of climate change adaptation is not a binding responsibility.
- There is a need to understand infrastructure interdependencies in detail, and to encourage cross-sectoral work to this end, at both national and local levels.

3.2. Issues for Greater Manchester

- Climate change adaptation and resilience needs to be intertwined with GM's focus on sustainable economic growth and regeneration, as set out in the overarching Greater Manchester Strategy.
- There is a need to integrate the short-term focus of civil contingencies work with the longer term focus on climate change adaptation. This is a key focus of the National Adaptation Programme and, given GM's current governance structure, there are good opportunities to do so at the conurbation scale.
- There are a number of unknowns with regard to the impact and consequences of extreme weather events on particular infrastructure types as well as the interdependencies between them in the context of extreme weather and climate change impacts. There are specific policy actions to understand and assess climate change risk to transport infrastructure (Greater Manchester Low Carbon Hub 2016: 10)
- There are a range of legislative drivers and policy guidance to encourage infrastructure operators to make their assets more resilient to the changing climate. A better understanding of the extent and nature of their activities would be beneficial for wider GM resilience goals.
- There are gaps in regulation particularly relating to making buildings resilient. However, recent government policy is trying to deregulate most sectors. There is scope for local policy to address this gap in national policy, particularly through design guidance at local level: GM's Green Infrastructure Framework is a good example.
- Guidance and strategic direction from national government is abundant in areas relating to climate change, flood risk and resilience. However, the main funding mechanisms are not

always clear, which is particularly true for SuDS and other GI schemes. Work that underscores the need for SuDS and GI, by identifying areas that would benefit most from such schemes, could encourage the uptake of such measures.

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Annex A

Scale	Title	Author	Year	Brief outline
GM	An ecological framework for Greater Manchester	AGMA (GM Ecology Unit)	2008	The Ecological Framework highlights a need for flood defence or alleviation through green infrastructure since 'safeguarding, enhancing and promoting access to [district's] green spaces that are of strategic importance in terms of defining the districts character, supporting biodiversity, recreation and other benefits' (p. 27)
GM	Green Infrastructure Framework	AGMA (Planning and Housing Commission)	2011	The Green Infrastructure Framework sets out GM's ambitions and policies for investing in, and encouraging the uptake of, GI. At GM level, the GI framework is one of a series of key documents that informs the preferred policy approach to delivering the Greater Manchester Strategy (GMS). The report provides a clear set of priority GI themes; the Framework offers a spatial representation of these themes to be reflected at the sub-regional level through the Greater Manchester Spatial Framework (GMSF).
GM	Transformation, Adaptation & Competitive Advantage: the Greater Manchester Climate Change Strategy (2011 - 2020)	AGMA	2011	The strategy sets out GM's plan to build a low carbon economy by 2020, reducing carbon emissions by 48% and reacting to the changing climate while creating future jobs and new industries in the 'green' sector. There are four headline aims; one of which is to 'Be prepared for and actively adapting to a rapidly changing climate'. Using the UK National Adaptation

				Programme as a guide, GM will 'strengthen our infrastructures, developing resilience strategies for energy, water, transport and building partnerships' (p. 11).
GM	Surface Water Management Plan	AGMA/JBA Consulting	2012	The Surface Water Management Plan (SWMP) project is essentially a study of surface water flood risk, recognising the cause and effect of flood hazard between districts and communities in GM. The plan identifies surface water flood hotspots in the conurbation, as well as potential areas where mitigation measures can be enacted. The document suggests the need to build capacity for stakeholders to act in issues relating to SWF.
GM	Greater Manchester Climate Change Implementation Plan (2015)	GMCA	2013	This Implementation Plan sets out the strategic actions GM intends to take to deliver its Climate Change (2012) and Low Emissions (2015) Strategies between 2016 and 2020. The strategy objectives include contributing to the sustainable economic growth, environmental quality, climate resilience and well-being. The implementation plan notes that there is a need to "[invest and deliver] major schemes in transport infrastructure; energy (heat and power) infrastructure, use and supply; building retrofit; and flood risk management, to enhance resilience." (p. 3)
GM	Climate Change and Low Emission Strategies Whole Place Implementation Plan for Greater Manchester (2016-2020)	GM Low Carbon Hub	2016	Given substantial changes in GM's governance structure as a result of devolution, the implementation plan for climate change was updated. There are five key goals which include 'rapidly adapting to a changing climate' along with critical objectives. The plan also includes potential measurements and monitoring as well as indicators although there are few of these relating specifically to adaptation. The focus of most of the aims is on mitigation.

GM	Greater Manchester Strategy - Stronger Together	GMCA/GM LEP	2013	The Greater Manchester Strategy sets out GM's plans for reforming public services and its drive for economic growth and prosperity. The vision is of a city region which has a good quality of life, a low carbon economy and a commitment to sustainable development. Explicit in this is the need to adapt to a changing climate with clear statements around the need to address the impacts of a changing climate and extreme weather as well as commitments to implement recommendations (p. 47).
GM	GM Growth Reform Plan	GMCA	2014	In line with the GM Strategy, the growth and reform plan outlines a vision for Greater Manchester to become a financially self-sustaining city, closing the gap between the tax that is generated through growth and the cost of delivering public services. The plan outlines public sector reform, the devolution of health and social care budgets, as well as plans for the financing of major infrastructure investments. There are no suggested actions but may set the tone for how climate resilience is approached in terms of governance and funding.
GM	Greater Manchester Community Risk Register	GM Local Resilience Forum	2015	In line with the Civil Contingencies Act 2015, the GM Community Risk Register assesses emergency risks that are likely to affect the local area and prepare plans to respond to a range of emergencies. Although mainly aimed at the general public, the Local Resilience Forum has a role in 'maintaining Business Continuity plans so that emergency and public services continue to function throughout periods of severe weather' (p. 15)
GM	Greater Manchester Spatial Framework (Draft)	GMCA	2016	The GMSF is the statutory spatial plan of the ten GM districts. The GMSF identifies where to deliver new housing, jobs, and infrastructure. There is an explicit focus on sustainable growth and development through the notion of 'environmental capacity', and the GMSF explicitly states that spatial planning will need to consider GM's climate change and resilience agenda. Green Infrastructure is identified as playing a key role in enhancing

				climate resilience.
Regional	One Agenda, One Economy, One North	Transport for the North	2015	This document emerged from a partnership of local transport authorities, local enterprise partnerships (operating across the north of England), the UK Government, Highways England, HS2 Ltd and Network Rail to develop a strategy for transport in the north of England. Climate change is not mentioned at all, and resilience is only included in the general sense of redundancy of the network.
GM	Greater Manchester Transport Strategy 2040.	TfGM	2017	The Greater Manchester Transport Strategy sets out a vision for the transport network that GM needs by 2040 to deliver long-term sustainable growth. Climate change is identified as a significant challenge, although specific impacts are not identified. The strategy regards investment as important: "We must also adapt to climate change and become more resilient through careful planning and targeted infrastructure investment over the coming years." (p. 13)
Regional	Water for Life and Livelihoods': Part 1: North West river basin district river basin management plan	Environment Agency	2016	The document, and accompanying maps and datasets, outline the plan for the north west of England to manage water in the NW RBD. The plan is in accordance with the EU Water Framework Directive and the Water Environment (Water Framework Directive) (England and Wales) Regulations 2003. The RBM plan provides a framework for protecting and enhancing the benefits provided by the water environment. The RBM plan affects land-use planning too because this has a direct effect on the water environment. Note that the risk assessments undertaken for the RBM plan only forecast risk up to 2027. Therefore, climate change risks have been restricted to the faecal indicator organisms risk assessment and the abstraction-flow risk assessment. The document includes an outline of measures that will be

				<p>taken up to 2021, and beyond to 2027, with a view to enhancing multiple benefits. The RBM plan should inform decisions on land use planning.</p>
UK	Reservoirs Act	Former DoE	1975	<p>The Reservoirs Act introduced the monitoring of reservoir levels. This was amended in the Flood and Water Management Act (2010) which turned attention towards ‘high risk’ reservoirs.</p>
UK	Security and Emergency Measures Direction	Department of Environment, Transport and the Regions	1998	<p>Although the direction is not related to climate change, it contains a mandate for water companies to provide water supply by some other means if there is failure or disruption.</p>
UK	The Green Book (with adaptation and infrastructure supplements).	HM Treasury	2003	<p>The Green Book provides advice to public sector organisations on how proposals should be appraised, before significant funds are committed – and also on how past and present activities should be evaluated. The revised editions (2013/15) include more guidance on appraising proposals that take account of long term approaches, and that are more thorough and robust. Supplementary guidance also includes that on adapting to climate change and also infrastructure spending in order to take account of resilience and interdependencies, amongst other things.</p>
UK	The Water Environment (Water Framework Directive) (England and Wales) Regulations 2003	Defra	2003	<p>These regulations transpose the EU Water Framework Directive into UK Law. Responsibility is considered to be that of competent authorities (e.g. the Environment Agency). The directive provides for the characterisation of river basins so that water is managed in hydrological and natural geographical areas, rather than administrative areas. As well as the monitoring, setting of environmental objectives and measures, the directive (and these</p>

				regulations) requires the development of River Basin Management Plans.
UK	The Orange Book	HM Treasury	2004 (first published in 2001)	The Orange Book is intended as guidance in order to provide a range of authorities tasked with the management of risk with advice on issues such as training, assessing risk, understanding the appetite for risk. Risk is understood as likelihood X consequence, and may be quantitatively or qualitatively judged.
UK	Civil Contingencies Act	Cabinet Office	2004	The Civil Contingencies Act is intended to increase the UK's resilience to a range of potentially disruptive acts. The CCA provides for actions at both a national and local/regional level in terms of planning for, and responding to, potential emergencies. The CCA is invoked when all other available powers have been exhausted (e.g. the Energy Act 1976) and thus provides powers for the national government to assume overall control in the case of an emergency. The CCA deals with a wide range of different risks including terrorism, cyber security, and extreme weather events.
UK	Civil Contingencies Act 2004 (Contingency Planning) Regulations	Cabinet Office	2005	The Civil Contingencies Act 2004 (Contingency Planning) Regulations 2005 further fleshes out key aspects of the Civil Contingencies Act 2004.

UK	Climate Change Act	UK Government	2008	<p>The Climate Change Act makes legal arrangements about climate change mitigation and adaption. It sets the requirements for the Climate Change Risk Assessment, the National Adaptation Programme and the adaptation reporting power. The Act empowers the Climate Change Committee (and adaptation sub-committee) to lead on this work.</p>
UK	The Planning Act	CLG	2008	<p>The Planning Act (2008) set up the infrastructure planning commission (now abolished) to approve Nationally Significant Infrastructure Projects (NSIP); national policy statements (NPS's) have been designated (12 to-date at 2016) under the act including fossil fuels, renewable energy, nuclear power and waste water; The Act also set up the Community Infrastructure Levy (CIL) which can fund infrastructure projects such as flood defences and green spaces.</p>
UK	Adapting to climate change: helping key sectors to adapt to climate change	Defra	2009	<p>This is statutory guidance, provided under the Climate Change Act (2008) that is particularly related to the Adaptation Reporting Powers. Following the guidance should aid authorities in developing a managed, adaptive approach to climate change risks, but most of all, lead to the changing climate becoming a key consideration in organisations' planning processes and decisions.</p>
UK	Flood Risk Regulations	Environment Agency	2009	<p>The Flood Risk Regulations transpose the EU Floods Directive into law in England and Wales. Under the Flood Risk Regulations 2009 the Environment Agency and LLFAs had to prepare preliminary flood risk assessments by December 2011. Completed by LLFAs, these PRFAs are published by the Environment Agency.</p> <p>There is also a duty on LLFAs with an agreed Flood Risk Area to publish flood hazard and</p>

				flood risk maps for all sources of flooding by December 2013 and flood risk management plans by December 2015. These flood risk management plans should set objectives for flood risk management and outline measures for achieving these objectives.
UK	Accounting for the Effects of Climate Change: Supplementary guidance to the Green Book	HM Treasury	2009	This document provides supplementary guidance to the Green Book with advice on accounting for the effects of climate change in terms of both mitigation and adaptation.
UK	National Policy Statement for Gas Supply Infrastructure and Gas and Oil pipelines (EN-4)	DECC	2009	The NPS for Gas is closely linked to EN-1, which is the overarching statement for energy. The NPS is developed in response to Section 5(9) of the Planning Act (2008) and sets out national policy for energy structure, particularly in terms of planning new infrastructure. Local planning authorities (LPAs) in preparing should utilise the NPS when planning their local impact reports. EN-1 covers climate change adaptation at a generic level, EN-4 provides further guidance for gas.
UK	Climate change adaptation reporting	Defra	2010	This entry comprises of documents to provide guidance for the infrastructure providers who are required to report on their identification of climate risks, and their actions towards mitigating these. The framework is a qualitative approach to evaluating the risk assessments within the Adaptation Reports and will also allow a synthesis of the strengths and areas for improvement both within and between sectors.
UK	Flood and Water Management Act	Defra	2010	The FWMA set out the differing roles and responsibilities for flood risk management; that is, the Environment Agency have oversight of coastal and river flooding, whilst local authorities have oversight of surface water flooding, with utility company responsibility for drains. The FWMA also places a duty on all flood risk management authorities to co-operate with each

				<p>other. There is provision for the creation of surface water management plans as well as the establishment of a national approving body for SuDS (not yet implemented - Jan 2016). Lead local flood authorities are required, under section 21 of the Flood and Water Management Act, to maintain a register of structures and features which are likely to have a significant effect on flood risk in their area.</p>
UK	Strategic Framework and policy statement (protecting infrastructure from Natural Hazards)	Cabinet office	2010	<p>This Strategic Framework and Policy Statement established a cross-sector programme to improve the resilience of critical infrastructure and essential services to disruption from natural hazards. The purpose is to develop a shared, consistent, proportionate and risk-based approach to delivering reductions in vulnerability over a number of years.</p>
UK	The Building Regulations	CLG	2010	<p>The Building Regulations consist of technical parameters that set the standards that should be achieved in construction. In addition, the regulations are procedural in that they set out the types of construction that require approval, and how that approval may be gained. The building regulations do not cover resilience.</p>
UK	Biodiversity 2020	Defra	2011	<p>The biodiversity strategy for England builds on the Natural Environment White Paper and provides a comprehensive picture of how the UK is implementing international and EU commitments. The strategy sets out the strategic direction for biodiversity policy for the next decade on land (including rivers and lakes). The aim is to: “to halt overall biodiversity loss, support healthy well-functioning ecosystems and establish coherent ecological networks, with more and better places for nature for the benefit of wildlife and people.” (p. 4). There are a set of outcomes from which to measure progress</p>

UK	Climate resilient infrastructure: preparing for a changing climate	Defra	2011	<p>This document applies to energy, ICT, transport and water infrastructure (i.e. the infrastructure networks) rather than all of the nine sectors identified in other UK policies. The main climate change issues identified are: rising temperatures, changing rainfall patterns and rising sea levels and, with that, potential increases in extreme weather events, such as storms, floods and droughts.</p> <p>The document proposes general adaptation/resilience actions. The role of government is to provide policy frameworks and strategies, guidance and information; action should be undertaken by investors, owners, operators, insurers, professional sectors.</p>
UK	Keeping the Country Running: Natural Hazards and Infrastructure	Cabinet Office	2011	<p>This document provides a model of resilience that does not depend on additional regulation or standard-setting, but shares best practice and advice to enable owners and operators of the UK's critical infrastructure to improve the security and resilience of their assets, with support from the regulators where relevant.</p>
UK	Localism Act	CLG	2011	<p>The Localism Act 2011 broadly aims to decentralise power, moving it away from central government. This includes: new freedoms and flexibilities for local government; new rights and powers for communities and individuals; reform to make the planning system more democratic and more effective; reform to ensure that decisions about housing are taken locally.</p>
UK	The Natural Choice: Securing the Value of Nature (Natural Environment White Paper)	Defra	2011	<p>The first natural environment white paper for 20 years, <i>The Natural Choice: securing the value of nature</i> sets out a vision in which 'the Government wants this to be the first generation to leave the natural environment of England in a better state than it inherited'. <i>The Natural Choice</i> announced the formation of Local Nature Partnerships (LNPs) supported by a £1 million start-up fund. <i>The Natural Choice</i> also created a Green Infrastructure</p>

				Partnership to support the development of green infrastructure (GI) in England, with a commitment to consider how green infrastructure can provide resilience to climate change.
UK	Strategic National Framework on Community Resilience	Cabinet Office	2011	This document provides a statement on the roles and responsibilities of communities in relation to community resilience to disasters. The framework is intended to provide the national statement for how individual and community resilience can work. It should be relevant to all hazards and threats, and all communities.
UK	Town and Country Planning (EIA) Regulations 2011.	CLG	2011	The process of Environmental Impact Assessment is governed by the Town and Country Planning (Environmental Impact Assessment) Regulations 2011 as amended. These regulations apply the EU directive “on the assessment of the effects of certain public and private projects on the environment” (usually referred to as the Environmental Impact Assessment Directive) to the planning system in England For new developments, an environmental assessment needs to consider the climate when considering the impact of new developments. Furthermore, the impacts should include direct and indirect effects, as well as effects over time. In addition, it is incumbent on the developer to demonstrate how these potential impacts will be mitigated. All new developments includes critical infrastructure development, therefore, there may be scope to include climate resilience actions within the scope of the environmental assessment.
UK	National Flood and Coastal Erosion Risk Management (FCERM) Strategy for England	Defra/ Environment Agency	2011	The National Strategy for Flood and Coastal Erosion Management (FCERM) is a statutory document, required by the Flood and Water Management Act 2010 FCERM details the action that all responsible authorities need to undertake to reduce the likelihood of flooding,

				and to manage the consequences. There is a specific focus on coordination across catchments and to support local decision-making and engagement. The major utilities and infrastructure providers are regarded as essential to the shaping of flood risk management, as well as taking into account the outputs of strategies and plans. Government's role is to provide insight and strategic direction.
UK	Overarching Policy Statement for Energy (EN-1)	DECC	2011	As with other NPS for infrastructure, EN-1 is in response to Section 5(9) of the Planning Act (2008) and sets out national policy for energy structure, particularly in terms of planning new infrastructure. Local planning authorities (LPAs) in preparing should utilise the NPS when planning their local impact reports. EN-1 provides generic guidance on taking climate change adaptation into account. The accompanying NPS provide further details specific to the infrastructure types.
UK	National Policy Statement for Fossil Fuel Electricity Generating Infrastructure (EN-2)	DECC	2011	The NPS for Fossil Fuel Electricity Generating Infrastructure is closely linked to EN-1, which is the overarching statement for energy. The NPS is developed in response to Section 5(9) of the Planning Act (2008) and sets out national policy for energy structure, particularly in terms of planning new infrastructure. Local planning authorities (LPAs) in preparing should utilise the NPS when planning their local impact reports. EN-1 covers climate change adaptation at a generic level, EN-4 provides further guidance for electricity generation.
UK	Understanding the risks, empowering communities, building resilience: the national flood and coastal erosion risk management strategy for	Defra	2011	The strategy is in response to Section 7 of the Flood and Water Management Act (2010). The FCERM strategy sets out a national framework for managing the risk of flooding and coastal erosion. It will help risk management authorities and communities understand their different roles and responsibilities and will be particularly relevant to Lead Local Flood Authorities (LLFAs) who assumed new responsibilities under the Flood and Water

	England			Management Act (2010). The strategy advises forward planning that takes account of climate change, coordinated action across catchments, and nature based solutions where possible.
UK	National Planning Policy Framework (NPPF)	CLG	2012	Section 10 of the NPPF deals with 'Meeting the Challenges of Climate Change, Flooding and Coastal Change'. The NPPF maintains a strong planning policy on avoiding and managing risks from flooding, based on the central role of local planning authorities in preparing local plans and in deciding applications for planning permission. The NPPF highlights that inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk, but where development is necessary, making it safe without increasing flood risk elsewhere. Separate guidance on Adapting to Climate Change has been produced. The NPPF does not apply to Nationally Significant Infrastructure Projects.
UK	Ports National Planning Statement	DfT	2012	In accordance with the Planning Act (2008), The Ports National Planning Statement outlines national government policies to deliver and develop new ports in England.
UK	National Adaptation Programme	Defra	2013	Produced by the UK Government, this is a register of actions aligned to risks identified in the national Climate Change Risk Assessment. The NAP is split into themes including Built environment; Infrastructure; Healthy and resilient communities; Agriculture and forestry; Natural environment; Business and local government. It looks most closely at the most urgent risk factors and sets out actions for a range of actors, including local stakeholders or organisations with a role / remit within GM around increasing local resilience to climate change. The programme includes tools and guidance to support infrastructure providers and

				operators.
UK	Aviation Policy Framework	DfT	2013	The Aviation Policy Framework is a high level strategy that sets out UK objectives for aviation policy, and how these objectives will be met. The framework notes the need for further research into climate change adaptation following the UK Climate Change Research Assessment, in particular: 'Further research is needed to investigate climate scenarios, probability of risks, timescales, adaptation options, investments and stakeholder interdependencies' (Section 2.58, pp. 53 -4).
UK	Climate resilient infrastructure: Preparing for a changing climate - Progress update report	Defra	2013	This document provides an update as to how the government with agencies and infrastructure owners and operators are meeting the actions set out in 'Climate Resilient Infrastructure: Preparing for a changing climate'. Notes the need for climate resilience work to be strengthened by bringing the Cabinet Office (through civil contingencies work) closer to the NAP (pp. 2 -3) 'Defra and the Cabinet Office aim to strengthen existing links between the National Adaptation Programme and central government preparations for civil emergencies emanating from natural hazards, accidents or malicious threats. One option currently under consideration is for government departments to incorporate longer term climate resilience into their future Sector Resilience Plans.'
UK	Water Act	Defra	2014	In order to protect water resources into the future, and to reform the market, the Water Act 2014 introduces a number of measures. Climate change, population growth and changes in demand are taken into account in the future oriented Water Act. The Act also addresses the challenges of extreme weather such as droughts and floods. OFWAT received greater powers in the context of resilience. The Act also gives the secretary of state the power to

				give directions to a water undertaker about the basis on which its water resources management plan is to be prepared (but only with a view to securing the ability of the undertaker to meet the need for supply of water to consumers) and these directions can require the plan to be based on specific assumptions around resilience and security of supplies in drought.
UK	Transport Resilience Review: A review of the resilience of the transport network to extreme weather events CM 8774	Richard Brown	2014	In light of flooding in 2013/14, the Department of Transport commissioned a review, led by Richard Brown, to appraise the resilience of the UK's transport infrastructure (road, rail, air, etc.) to extreme weather events both now and under a changing climate. The call for evidence resulted in the formulation of 63 recommendations which could be divided into actions for the short term and long term.
UK	National Risk Assessment (National Risk Register of Civil Emergencies)	Cabinet Office	2015	A confidential National Risk Assessment is undertaken by the UK government, which is published as the National Risk Register. The NRA and NRR are intended to capture the range of emergencies that might have a major impact on all, or significant parts of, the UK. These are events which could result in significant harm to human welfare: casualties, damage to property, essential services and disruption to everyday life. The risks cover three broad categories: natural events, major accidents and malicious attacks.
UK	Heatwave Plan for England	Public Health England	2015	The Heatwave Plan for England provides information, guidance and suggested actions on how to prepare for and respond to heatwaves.
UK	Infrastructure Act	HM Treasury	2015	The Infrastructure Act (2015) is a wide ranging document that aims to stimulate national infrastructure programmes (including housing) through the planning and development system. The Act covers transport, housing, regeneration, infrastructure and energy. The Act

				proposes the creation of strategic highways companies to replace strategic highways authorities; government investment in cycling and walking; the discharge of certain types of planning conditions; the transfer of publicly held land; the local land charges service; and shale gas extraction. No direct impact on risk and resilience relating to CI, however, the act has implications for the future. If there is more development and this is a national aim, then the resilience agenda should come to bear in order to protect investments.
UK	Valuing Infrastructure Spend: Supplementary guidance to the Green Book	HM Treasury	2015	The Green Book provides advice to public sector organisations on how proposals should be appraised, before significant funds are committed – and also on how past and present activities should be evaluated. The revised editions (2013/15) include more guidance on appraising proposals that take account of long term approaches, and that are more thorough and robust. Chapter 3 covers interdependencies and resilience. Various calculation tools and models are discussed in order for infrastructure planners to value their projects.
UK	Planning Guidance (ID 6) Climate Change	CLG	2015	This is supplementary guidance to the NPPF. The document provides guidance as to the types of climate change adaptation actions that could be undertaken. Suggests integrating mitigation and adaptation (look for the "win-win"). In addition, working in future adaptability into new developments
UK	Cities and Local Government Devolution Act	CLG	2016	The devolution of power to local authorities/combined authorities with an elected mayor has been limited to certain domains; however, there is flexibility over transferred powers in the future. It is reasonable to assume that this could mean the potential transfer of powers relating to climate change/resilience.

UK	National Infrastructure Delivery Plan 2016–2021	Infrastructure and Projects Authority	2016	<p>The National Infrastructure Delivery Plan updates, and replaces, the National Infrastructure Plan (2010). There is a focus on how infrastructure spending can be used to drive housing and regeneration, as well as links to social infrastructure projects. The plan creates two new bodies to cover both short (to 2020-21) and long term (to the 2050s) planning: through 2 newly-created bodies, the Infrastructure and Projects Authority and an independent National Infrastructure Commission. As well as covering traditional infrastructure systems such as transport and energy, the Plan also examines flood defence spending, housing, and social infrastructure (i.e. capital expenditure towards these).</p>
UK	Housing and Planning Act	CLG	2016	<p>The aim of the Housing and Planning Act legislation is to increase the number of homeowners, whilst raising house building levels. The legislation includes the mechanisms through which social housing can be sold to tenants, as well as automatic planning permission for brownfield sites. The Secretary of State for CLG can review the provision of sustainable drainage in developments. In addition, councils are to maintain a register for all brownfield land (with the intention of giving quick planning permission for housing development).</p>
UK	UK Climate Change Risk Assessment	Defra	2017	<p>This is the UK's second climate change risk assessment. The first was published in 2012 and led to the National Adaptation programme. The CCRA is updated every five years.</p> <p>The method involved assessing a number of climate change risks and opportunities. The chapters are organised sectorally, and is scored on the basis of urgency. Identified areas where more action relating to GM is required are: understanding interdependencies and the risks from cascading failures; understanding the risks to infrastructure services from river, surface water, and groundwater flooding; the risks of sewer flooding due to heavy rainfall; risk to transport networks from slope and embankment failure; and risks to public water</p>

				supplies from drought and low river flows.
UK	Emergency Preparedness	Cabinet Office	2006 (update d 2012)	This is linked to Emergency Response and Recovery. The guidance provides details of what the Civil Contingencies Act, and accompanying regulations, requires; good practice guidance on how Category 1 and 2 responders should carry out their duties to comply with the legislation; and information that is not governed by the legislation
UK	Emergency Recovery and Response	Cabinet Office	2010 (update d 2013)	This is linked to Emergency Preparedness. The guidance provides details of what the Civil Contingencies Act, and accompanying regulations, requires; good practice guidance on how Category 1 and 2 responders should carry out their duties to comply with the legislation; and information that is not governed by the legislation. This is particularly true of how to recover and respond to an emergency under an Integrated Emergency Management (IEM) approach.
UK	Sector Resilience Plans	Cabinet Office	2010 (update d yearly)	Sector resilience plans were prompted following the recommendation of the Pitt Review to look at the vulnerability of the UK's CI to flooding. A Critical Infrastructure Resilience Programme was established as collaboration between owners/operators of critical infrastructure in the nine recognised infrastructure sectors, government departments sponsoring these sectors, and regulators. This led to sector resilience plans, firstly in 2009 but updated yearly. Initial plans addressed flooding only but have later included other hazards. They also focus only on the CI in each sector although interdependencies are recognised. Note that individual sectoral plans are classified, but a document summarising them is publicly available.

UK	National emergency plan for downstream gas and electricity	DECC	2012 (updated 2014)	The national emergency plan for Downstream Gas & Electricity (NEP), outlines the national arrangements established between DECC, the downstream gas and electricity industry, the Office of Gas and Electricity Markets (Ofgem) and the European Commission and other interested parties. The document identifies who is responsible for what, the alert guidance, and the chains of command at local and national level.
UK	National Flood Emergency Framework	Defra	2013 (updated 2014)	Emerging from the recommendations of the Pitt Review, the National Flood Emergency Framework aims to provide forward looking and coordinated action for all of those dealing with a range of different types of flooding. This Framework provides information and planning assumptions to inform and encourage contingency planning. It does not provide detailed operational guidance for individual emergency planners or responders.
UK	Network Regulation - the Revenue = Incentives+Innovation+Outputs (RIIO) Model	Ofgem	2013/16	This is a performance based model for setting the Network companies price controls and is used by Ofgem to incentivise in adaptation by network operators. The RIIO model The RIIO approach allows operators the opportunity to put forward any incremental costs associated with adaptation actions. This is primarily achieved through the Environmental Discretionary Reward (EDR) Scheme which incentivises the industry to move to a low carbon system and to implement high standards of environmental management. There are a number of RIIO guidance documents relating: RIIO-T1 (2013) (gas and electricity transmission); RIIO-GD1 (2013) (gas distribution); RIIO-ED1 (2016) (electricity distribution).
UK	National Preventive Action Plan (PAP) for Gas	DECC	2014 (amended 2015)	The preventative action plan for gas completed for EU Regulation security of gas supply 994/20102. The document outlines the measures needed to mitigate the risks affecting the security of gas supply in the UK. In 'actual or threatened emergency' situations, then exceptional powers for fuel and electricity can be assumed by the government.

UK	National Policy Statement for National Networks	DfT	2014	In accordance with the Planning Act (2008), The National Networks National Policy Statement (NPS) outlines national government policies to deliver and develop nationally significant infrastructure projects on the national road and rail networks in England. It provides planning guidance for promoters of nationally significant infrastructure projects on the road and rail networks and has a well-developed section on adapting to climate change (Sections 4.4 – 4.47) including the identification of adaptation measures
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