ICED
Infrastructure & Cities for Economic Development

Climate Resilient Infrastructure:

UK Industry Best Practice

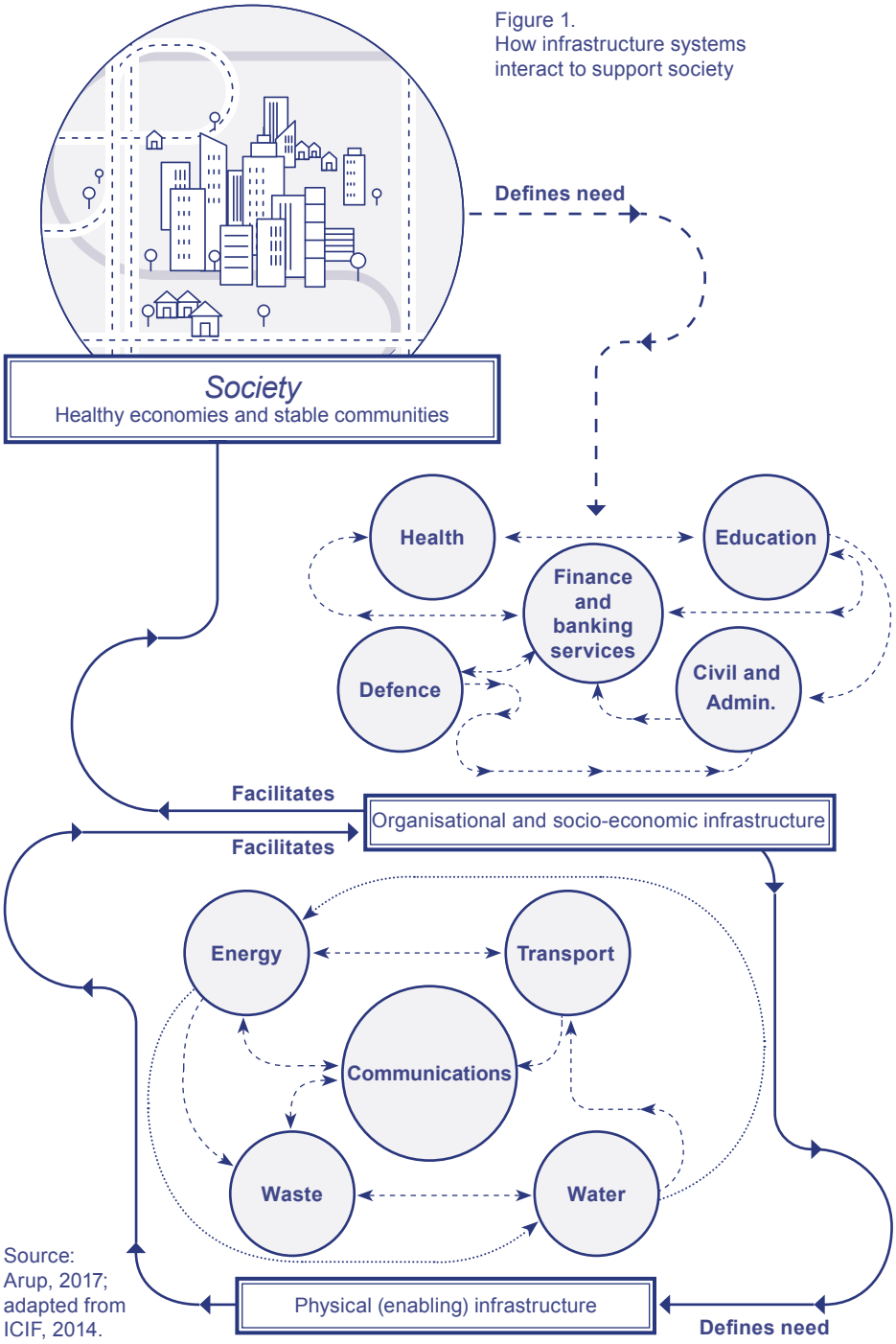
Introduction

This briefing note provides an overview of UK built environment industry best practice approaches to **planning**, **designing** and **assessing** climate resilient infrastructure. Many definitions of climate resilience exist within this emerging and evolving field of work*. Current best-practice industry views on climate resilient infrastructure can be summarised as:

"A lifecycle approach to infrastructure delivery, which accommodates climate risk and uncertainty, and adopts performance-based approaches to enhance the resilience of communities and economies to existing and future climate impacts"[1].

Infrastructure systems are complex and interconnected with other physical, economic and social systems, as illustrated in Figure 1. Defining a common approach to climate resilience that is applicable across multiple assets, locations and infrastructure types can be challenging.

Figure 1.
How infrastructure systems interact to support society



Source:
Arup, 2017; adapted from ICIF, 2014.

Drivers

The main industry drivers for climate resilient infrastructure can be categorised as "**must-do**", "**should-do**" and "**could-do**" drivers, as shown in the diagram on the following page.

*Practitioners should not be confused by the existence of multiple definitions in this field; the concept of resilience is essentially straightforward.

"Must do"

Legislation, policy frameworks, funding requirements

"Should do"

Awareness of climate risks, 'peer pressure', competitive advantage

"Could do"

Foresight and innovation, enlightened self-interest

In the UK and Europe "must do" drivers include the amended EU Directive for Environmental Impact Assessments[2], the UK 2008 Climate Change Act[3], the National Adaptation Reporting Power (ARP)[4], the UK Climate Change Risk Assessment (CCRA)[5], and Sector Resilience Plans (SRPs)[6]. These require industry to assess and mitigate risks to build resilience, and report on these efforts.

The "should do" drivers also incentivise industry to build infrastructure resilience. Increased awareness and direct experience of climate risks puts pressure on infrastructure owners and operators to address the issue of climate resilience. The financial and reputational benefits of managing and addressing climate risk, coupled with competitiveness in the private sector, means resilience can make business sense.

The "could do" drivers are voluntary actions taken by infrastructure owners and operators to enhance climate resilience, taking into account interdependencies with other systems and multiple benefits for other stakeholders.

Strategies

The UK Cabinet Office has outlined four strategies to manage infrastructure risks – from both climate and non-climate related hazards – and to build resilience[7]. These can be categorised further into "pre-event" (planning and design) and "post-event" (planned operational responses to both deal with and recover from events).

"Pre-event" (design)		"Post-event" (operation)	
Resistance	Providing enhanced protection of infrastructure components	Redundancy	Increasing capacity, providing alternative connections and backup systems that can be used in case of disruption
Reliability	Improving infrastructure reliability to enable operation under a range of conditions	Response and Recovery	Building capacity in organisations and communities to deliver an effective response to, and recovery from, climate disruption

Pre-event strategies include designing new infrastructure for future climate parameters, retrofitting existing infrastructure and performance-based design. In established economies such as the UK, most critical infrastructure already exists - new major infrastructure projects are the exception rather than the norm. Therefore, interventions and retrofitting are often required.

A performance-based design goes beyond traditional design standards to achieve a greater focus on tolerable performance (the response should a climate hazard occur) from the earliest planning stage.

Post-event strategies include emergency response plans, targeted communication, cross-sector collaboration and informed decision-making. This places greater attention on operation and management. Greater collaboration between stakeholders and different sectors enables better understanding of interdependencies, increased preparedness in the event of disruption and the capacity to make informed decisions. Planning for a 'patch and repair' approach to infrastructure damage may be justifiable on cost-benefit grounds, if safety risks and other unacceptable risks are adequately managed.

Performance-based design - example

A road in a flood-prone area, which is designed for operation 350 days per year, supported by: contingency planning; short-term alternative forms of connection, and awareness-raising activities allowing road users to adapt at times of reduced service.

Capital, operational and disruption costs - example

The 2014 railway collapse at Dawlish in Devon in south-west England resulted in a repair cost of £45 million, whilst the cost to the economy of the disruptions were £1.2 billion. The potential savings lost were significant, due to a lack of advance investment in effective repair or preventive measures.

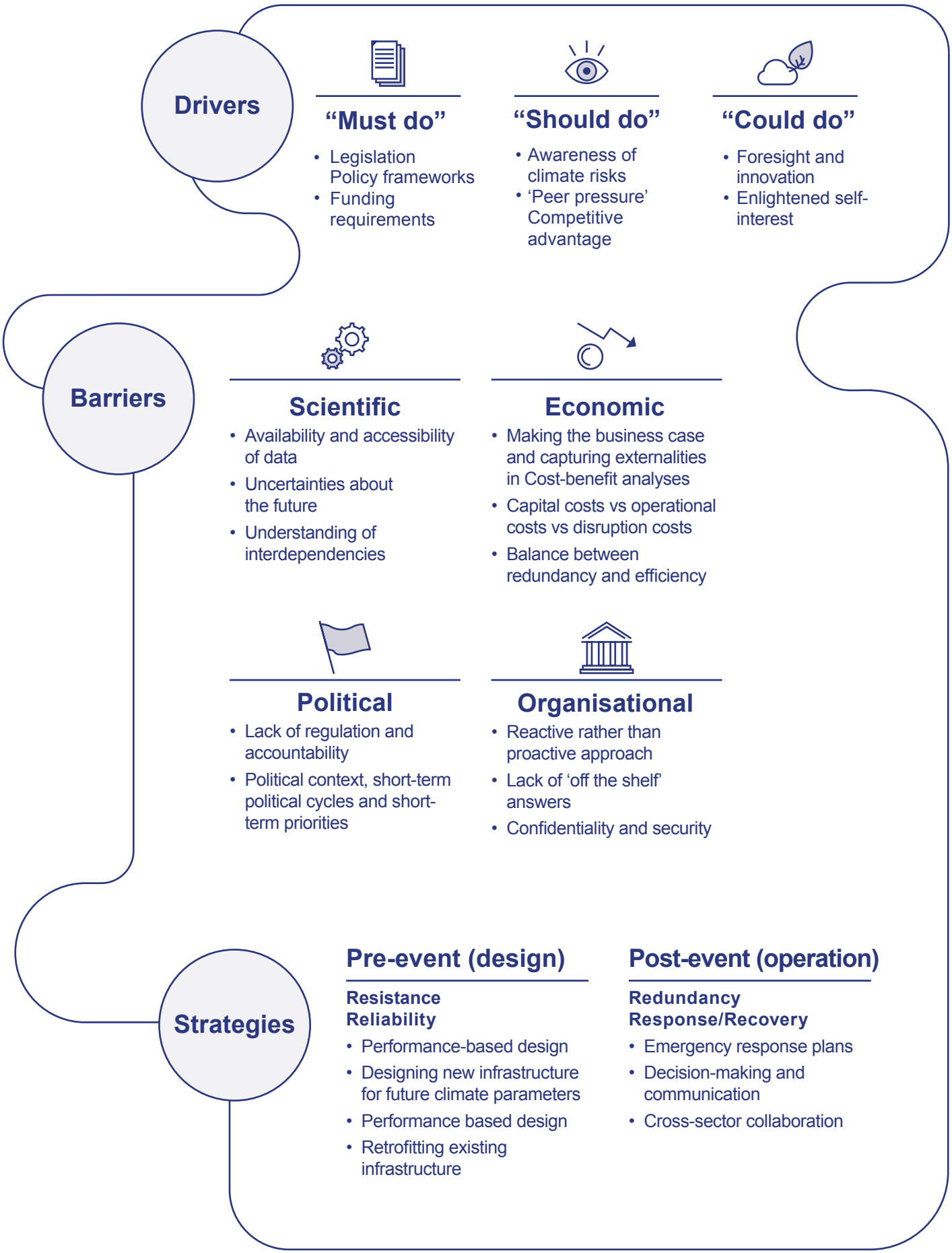


Figure 2
Drivers and barriers in implementing climate resilience strategies
Source: Arup, 2017

Examples

The boxes below highlight examples of best practice in climate resilient infrastructure by design and engineering companies in the UK and beyond. These cover a range of infrastructure sector examples (water, transport, energy, building systems), project types (new build, existing infrastructure, strategic study) and strategy types (performance based design, effective planning, emergency response, cross-sector collaboration, retrofit).

Kuala Lumpur SMART Tunnel

Consultant
Mott MacDonald

Sector
Water and transport

Project type
New build/infrastructure delivering resilience

Strategy type
Design – new build/performance-based design

Description
A tunnel serving both as a motorway and for diverting floodwaters from two major rivers; in extreme floods, the road decks are flooded to increase stormwater capacity. Resilience provided through building-in at design stage and having effective event response plans.

Transport Scotland Road Resilience

Consultant
AECOM

Sector
Transport/highways

Project type
Existing infrastructure/strategic study

Strategy type
Operation – effective planning

Description
A review of historical impacts, flood maps and future climate projections, as well as network vulnerability analysis, feeding into a risk assessment allowing for the development of effective adaptation responses.

Network Rail risk and resilience advice

Consultant
Arup

Sector
Transport/rail

Project type
Existing infrastructure/strategic study

Strategy type
Operation – effective planning/emergency response plans

Description
Key strategic advice for the enhancement of Network Rail's earthworks policy for Control Period 6, focussing on weather threats and criticality assessments.

High Speed 2 (HS2) Phase One and Phase 2a

Consultant
Arup

Sector
Transport/rail

Project type
New build

Strategy type
Operation – effective planning/ greater cross-sector collaboration

Description
A comprehensive and integrated approach to the assessment of climate change impacts and risks relating to HS2 as part of the Environmental Impact Assessment (EIA), informing the development of new guidelines to integrate climate change adaptation and resilience into EIAs.

Toronto Emergency backup power

Consultant
Mott MacDonald

Sector
Energy

Project type
Existing infrastructure/strategic study

Strategy type
Operation – effective planning

Description
A risk assessment exploring utility, climate change, maintenance and operational risks affecting electrical power systems in Toronto, resulting in a response plan for potential failures at critical facilities.

Siemens Toolkit

Consultant
Arup, Siemens

Sector
Energy, water, transport, building systems

Project type
Existing infrastructure/strategic study

Strategy type
Design – retrofit

Description
A case study evaluating the contribution intelligent technologies can make in increasing resilience, considering the costs and benefits of investing in resilience interventions for New York City's electrical grid.

Source: Arup, Mott MacDonald, AECOM, Siemens, 2016

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