

# Innovate UK

Technology Strategy Board



## The business case for adapting buildings to climate change: Niche or mainstream?

by Matt Thompson, Ian Cooper  
& Bill Gething

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# Foreword

## The Design for Future Climate legacy - kickstarting innovation

**Innovate UK's Design for Future Climate, Adapting Buildings (D4FC) programme generated a substantial body of evidence for how different buildings exposed to different climate risks can best be adapted for a changing UK climate.**

The design teams involved developed ingenious approaches and fresh thinking tailored to their buildings' unique circumstances, demonstrating the depth and excellence of the UK built environment professionals' capacity for innovation.

These design teams are now innovators in the field, putting them at the absolute cutting edge of climate change adaptation thinking and thus first in line for commercial adaptation work.

They also leave a handsome legacy of publicly funded open-access knowledge for the benefit of the rest of the building design industry. The information in the D4FC projects' final reports, along with several summary reports, contains a rich seam of intellectual capital that can be used to establish a consensus for future practice. These reports are freely available from <https://connect.innovateuk.org/web/design-for-future-climate/projects-outputs>.

The full version of this report can be downloaded from <https://www.gov.uk/government/organisations/innovate-uk>.

The subject is complex and full of uncertainties, but for firms who respond it seems likely that there will be early adopter commercial advantages as climate hazards become more prevalent and as pressure on clients to consider adaptation grows.

Properly managed and exploited, the momentum gained should put the UK at the forefront of the dawning international market for adaptation services in the built environment, which grew by over 5% last year.



A handwritten signature in blue ink that reads "Mark Wray".

**Mark Wray**

Innovate UK

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# Endorsements

**Marks & Spencer has been actively managing climate change risk in our supply chains and property estate since 2010, as part of our sector - leading Plan A strategy, and our participation in the Design for Future Climate programme has enabled us to enhance our bank of knowledge and share our insights.**

For too long, the issue of climate change resilience and adaptation in buildings has been seen as a subject of special professional interest. In this report Innovate UK recognises that adapting buildings to climate change needs a higher place on the agenda of businesses and their boards if the UK is to continue to be competitive in a commercial world.

This report sets out, with clear evidence, references, quotes, ideas and best practice from the Design for Future Climate programme, why and how we should consider adaptation. It brings together, with concision and accuracy, multi-sector viewpoints that deal with every angle of any issue relating to climate change risk in building design and leaves no stone unturned.

It moves the case for change several steps forward in a single effort – and that means that it will be an invaluable tool not just for those who currently understand the issue, but also for those whom we must still persuade.

## **Sylvie Sasaki**

Property Plan A Project Manager  
Property & Store Development, Marks & Spencer



**Continuing to design for yesterday's climate is exposing our buildings and their occupants to significant risks.**

Hot summers and heat waves, as well as floods and drought, are expected to become more common with climate change. In many cases simple, low cost design changes can make all the difference – creating better spaces in which to live and to work, able to safeguard peoples' health and productivity, and cope more readily with weather extremes. The Design for Future Climate project is an excellent resource, with lessons from experience and practical advice for both policymakers and practitioners on how to design buildings fit for the decades ahead.

## **Daniel Johns**

Head of Adaptation  
Committee on Climate Change



**Cover image:** Ebbw Valley School entrance shows how careful consideration of orientation and glazing can allow sunlight to enhance spaces without leading to overheating (Building Design Partnership for Blaenau Gwent County Borough Council)

# Executive summary

**This report analyses the drivers that affect the market for professional building design services to ready buildings for the changing climate. Recent Intergovernmental Panel on Climate Change (IPCC) reports confirm the climate trends that make adaptation important and urgent.**

Even small increases in average temperatures and their consequent effects on the intensity and frequency of extreme weather events can have far-reaching direct consequences for the built environment; complex indirect consequences will exacerbate the situation.

The technical challenge of adapting to future climate change in the built environment is to optimise building design now for the most effective phased transition to what will be needed in the future. Since the lives of buildings are measured in decades, this means anticipating the future and developing a gradual adaptation strategy that makes use of maintenance cycles for timely, effective and proportionate upgrades.

## Extreme weather in the UK?

2005	Flooding	2009	Flooding	2013	Hot weather
2006	Drought	2009	Snow and ice	2013	Storms
2006	Heatwave	2010	Flooding	2013	Flooding
2007	Flooding	2010	Snow and ice	2014	Flooding
2008	Flooding	2012	Drought	2014	The wettest January and driest September on record in the UK
2008	Snow and ice	2012	Flooding		

Source: Climate UK

However, some aspects and elements of buildings – such as their location, orientation, foundations, ceiling heights, glazing ratio, and so on – cannot easily or viably be adjusted in maintenance cycles but are nonetheless fundamental to a building’s ability to cope with future climate. If these fundamental design features cannot cope, buildings risk becoming ‘stranded assets’. A single such stranded asset is a private concern for the owner or occupier. However, a large number of stranded assets in all economic sectors across the UK is a public concern.

At the moment, the UK market for adaptation services from building designers is limited, constrained by, among other things, a return on investment for clients that is perceived to be poor, how distant the risks are in time, and uncertainty. Even prior experience of severe climate impacts appears not to motivate clients, indicating a ‘lightning won’t strike twice’ inertia in the market.

The reluctance from construction clients dampens the professional building design sector’s motivation to get involved. Investing in adaptation skills looks like a poor bet given the number of stronger markets for building design services.

However, there are some signs that pressure is mounting on clients from other sources, notably the insurance industry, investment institutions and, of course, other financial stakeholders, many of whom retain long-term interests in buildings after the construction client has moved on.

Also, many construction clients are waking up to the opportunities presented by climate change. As impacts hit and public awareness grows, resilient buildings will become important for maintaining a commercial advantage over business competitors and for demonstrating corporate social responsibility.

Finally, climate scientists are steadily amassing evidence that makes the changing climate increasingly difficult to ignore, improving certainty and paving the way for new professional design standards.

“The intensity and frequency of extreme weather can have far-reaching effects on buildings.”

# Seven key messages

**1**

The market for design services to adapt buildings to future climate change remains very limited

**2**

The limited market is not an excuse for building design professionals to do nothing

**3**

Construction clients risk procuring stranded assets if they do not heed climate change risks

**4**

The Government must signal that adaptation in the built environment is a critical issue

**5**

At present, the construction and property industries have no adaptation plan to tackle climate change

**6**

Clients and professionals urgently need educating in climate change adaptation for buildings

**7**

There is a need for a programme of monitoring and evaluating the performance of climate adapted buildings



# Recommendations

## Clients

- Clients should adopt appropriate procurement strategies and look to appoint competent building designers to manage the risk from climate change of stranding the assets they build
- Clients should collaborate with building designers to produce new advice for developing briefs that emphasise the needs of all financial stakeholders
- Construction client bodies, with the help of academic researchers and commercial suppliers to the industry, should develop construction client decision-making tools that accommodate future uncertainty

## Building design practice

- Professional institutions in the built environment should raise climate change adaptation up their list of priority concerns, and promote continuing professional development, lobbying and advances in professional knowledge and codes of practice
- Professional institutions should update standard terms and conditions for professional contracts and project management practice to account for climate change adaptation services
- Industry should develop an authoritative index of climate-readiness for buildings that allows clients to promote their buildings' credentials
- Building design firms should incorporate the adaptation design process into their project management in the same way that tabs are kept on, for example, regulatory compliance or health and safety

## The construction industry as a whole

- Professional institutions in the built environment and academic researchers should develop a protocol for assessing the risk to buildings from climate change hazards
- Professional institutions in the built environment, academic researchers and commercial suppliers to the industry should develop computational tools to standardise the way that climate change projections can be used by building designers
- Professional institutions in the built environment, academic researchers and commercial suppliers to the industry should develop and maintain a simple set of ratios for different building types as a shorthand to understand the relationship between capital expenditure and operational expenditure

## Policy makers

- Avoiding completely new legislation, Government should co-ordinate the updating of standards, planning and Building Regulations to accommodate climate change adaptation as soon as possible. The use of future weather data should be required by Building Regulations at their next revision, and could mandate a key role for phased adaptation plans as a way to allow for phased adaptation
- The Government should maintain research into climate change to reduce the uncertainty of future climate impacts, particularly those aspects that affect the built environment
- Government should support strategic action by industry to monitor, disseminate and promote climate change adaptation information about the built environment to developers, clients, design professionals, constructors, facilities managers and tenant organisations
- Government should require public building procurement and maintenance regimes to consider future climate change and the development of buildings with adaptive capacity
- In partnership with Government, industry should establish a programme of longitudinal demonstration projects, monitor their performance and publish the results openly
- In partnership with Government, industry should establish a programme of research to reduce the uncertainty of future climate impacts on the built environment at the local site-based scale

### New regulation for adaptation?

**The Adaptation Sub-committee's progress report<sup>1</sup>, published in July 2014, echoes many of the conclusions of this D4FC report. It compiles evidence for the Sub-committee's first statutory report to update the Government's National Adaptation Programme, due in 2015.**

As well as flooding, the Sub-committee highlights the risk of overheating. In particular, it says that there is a 'fundamental need to adapt the existing building stock and design new buildings to be safe and comfortable in a hotter climate.' It also recognises the existing market failure: 'Including passive cooling measures in buildings at the design stage is more cost-effective than retrofit, but the health benefits of these measures will fall to the householder while the developer incurs the up-front costs.'

Significantly, the Sub-committee identifies that Building Regulations 'do not account for the health risks from overheating now or in the future', and therefore concludes that 'a standard or requirement is needed in order to ensure new homes are built to take account of the health risks of overheating.' It calls on Government to review the evidence and evaluate options for a standard or other requirement on overheating. It also recommends that DECC reviews the Standard Assessment Procedure<sup>2</sup> in relation to overheating.

The Sub-committee also identifies other roles for Government in raising awareness and providing information, including:

- the Government should consider how to build awareness of options for reducing internal heat gains in housing and encourage their uptake through better information to householders. At the request of Government, the Zero Carbon Hub<sup>3</sup> is currently developing a project to assess the case for action on dealing with overheating in homes
- the Care Quality Commission<sup>4</sup> should consider setting standards for maximum temperatures in hospitals and make sure staff can control internal temperatures
- more information is needed to be able to assess preparedness for other health impacts including those related to ground level ozone, UV radiation and pathogens, and the resilience of health sector buildings such as hospitals and care homes to flooding and subsidence
- tackling flood risk will be the most cost-effective and sustainable approach to keeping flood insurance affordable in the long-term. The Government should introduce without further delay the Flood and Water Management Act provisions to require sustainable drainage in new development, also recommended by the Pitt Review
- the Government should consider how best to encourage businesses to enhance their resilience to flooding.

“We need to adapt new and existing buildings to be safe and comfortable in a hotter climate.”

<sup>1</sup> Adaptation Sub-committee. (2014). *Managing climate risks to well-being and the economy: progress report*. London: Committee on Climate Change. [http://www.theccc.org.uk/wp-content/uploads/2014/07/Final\\_ASC-2014\\_web-version.pdf](http://www.theccc.org.uk/wp-content/uploads/2014/07/Final_ASC-2014_web-version.pdf)

<sup>2</sup> The Standard Assessment Procedure (SAP) is the methodology used by the Government to assess and compare the energy and environmental performance of dwellings.

<sup>3</sup> The Zero Carbon Hub has responsibility for achieving the Government's target of delivering zero carbon homes in England from 2016.

<sup>4</sup> The Care Quality Commission monitors, inspects and regulates health and adult social care services to make sure they meet fundamental standards of quality and safety.



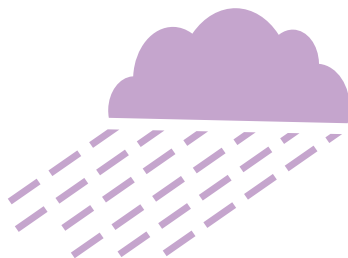
## The context

**This legacy report from the D4FC programme responds to the Government's National Adaptation programme and considers adaptation to climate change at the scale of individual buildings. It identifies that the need to have a plan for adapting the UK's stock of buildings is already urgent.**

Climate change in the UK has consequences for the built environment, chiefly health impacts (including loss of life), economic losses, the level of internal environmental 'comfort', increases in energy demand, and productivity losses.

Unfortunately, the steps needed to assess the risks from climate change and then to design appropriate responses are complex and beset by uncertainty. Also, climate change risk is just one class among many risks affecting buildings.

Clients increasingly recognise the issue but, in relation to other business or operational concerns, climate change impacts seem still too distant, too uncertain, and adaptation currently may not carry a compelling return on investment. There are many other, smaller barriers to clients commissioning adaptation services.



## Client profiles

**Although very important, commissioning building work is not the only logical response to climate change risks. Valid alternatives for clients include accepting the risks, transferring them, avoiding them altogether, and behavioural or management measures.**

There are many different kinds of client, and the extent to which they might be interested in adaptation varies enormously. Of course, the client is not the only financial stakeholder in their building: insurers, investors, tenants, for example, hold some sway over design decisions. The design brief should seek to protect their interests as well.

“The need for a plan to adapt the UK's stock of buildings is already urgent.”



100 City Road, London, an optimal solution based on owner and user adaptation measures (Arup)

Although less influential than the business case barriers, some factors will make clients more likely to consider adaptation strategies. For example, having suffered several previous climate impacts, already being engaged in the topic, being concerned about reputation and corporate social responsibility, having financial stakeholders pushing them to do so, or gaining a competitive advantage or exploiting new business opportunities by doing so.

“The design brief should seek to protect client, insurers, investors and tenants.”

### Rules of thumb

**Building designers can use the following rules of thumb to profile their clients' interest in adaptation.**

#### Clients' financial approaches

The business case for adaptation becomes stronger:

- if costs and benefits over time can be taken into account in establishing initial capital expenditure
- if adaptation gives the client genuine competitive advantages and allows them to exploit new opportunities
- if all the project's financial stakeholders can be shown to favour it
- the more the client's business processes and decision-making are integrated, and able to respond to new factors, and involve fewer people.

#### Clients' levels of engagement

The business case for adaptation:

- becomes stronger the more enduring the client's stake in the building
- is boosted when the client's fundamental purpose or core business objectives encourage it to engage with the issue
- becomes stronger the more impact adaptation has on the common good, especially if the adaptation is very visible.

#### Vulnerability of clients' buildings and operations

The business case for adaptation becomes stronger:

- the more vulnerable and likely to be affected the client's priorities are
- the more frequently and seriously the client has experienced the consequences of extreme weather events
- with more certainty of future risk.

#### Clients' decision-making

The business case for adaptation:

- is more willingly accepted by clients the more robust the rationale is and the more convincingly it is communicated
- becomes stronger when the decision-making processes can make sense of underlying uncertainty.

#### Clients' attitudes to design

The business case for adaptation becomes stronger:

- when the measures' technology is tried and tested, and the cost-benefits are pronounced
- the more robust evidence there is that it carries on working over time
- the more amenable the client is to innovation and the better the design team is at allaying clients' real or misplaced fears
- the more the client can see that it is part of the building designer's normal service and well established in-house practice.



## Building designer profiles

**Building designers have a professional duty to understand the potential implications of climate change, discuss them with clients, and act accordingly. Over time, it seems likely that liabilities will arise for building designers to take reasonable account of future climate change. As a consequence, building designers should at least inform clients about climate change risks, and record the outcome.**

“Designers have a duty to understand the impact of climate change and discuss it with clients.”

All building designers have their own unique strengths, special interests, and particular characteristics that determine the kinds of projects they are suited to. This reflects their overarching design philosophy and experience, and shapes the kinds of clients they attract and the emphasis they put on different issues.

To be capable of offering adaptation services, building design firms need to be:

- **open to innovation:** willing trying new things on live projects and committed to voluntary research and development and continuing professional development
- **enthusiastic about the subject:** knowledgeable about climate change science, clear-sighted about its impact on buildings, and good at communicating the issues
- **interdisciplinary:** designing from first principles, considering impacts holistically, and having the enthusiasm and skills to work collaboratively with other members of the team
- **aspiring to best practice:** the opposite of merely delivering regulatory compliance or only doing the minimum that reduced fees permit.

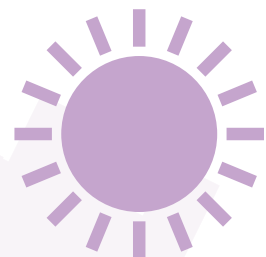
There is a micro-market for adaptation services, suited to only a few types of building design firm. Business models are restricted by adaptation’s innovative status and are either rolled up with or bolted on to standard service. For the majority, however, exploiting the opportunity is currently hard to justify in the context of other design issues, the still tentative economic recovery, and the reluctance of clients.

The skills and competences for delivering adaptation services are extensions of existing practice, informed by new principles. That said, lack of regulation and standards – consensus – hinders practice. There are other difficulties for building design professionals. For example, the underlying data informing adaptation design decisions are presented in an unfamiliar probabilistic format that is not easy to understand and communicate.

Adaptation services currently add time to the programme and are potentially inefficient. However, there are opportunities to streamline it significantly, especially if the Building Regulations and standards are updated to account for future climate conditions.



**D4FC:** Technical Hub at EBI, Cambridge, showing detailed solution for reducing solar gain/glare (Aecom)





## Executive summary

### New business competences for building designers?

**Building designers should favour passive adaptation design measures to avoid compromising efforts to mitigate climate change. However, they should recognise that these may not be sufficient to cope with climate change from mid-century onwards when, for instance, active assistance may be needed for cooling.**

The key deliverable from a climate change adaptation service is the phased adaptation plan. For maximum effectiveness, adaptation should be considered as early as possible in the project life.

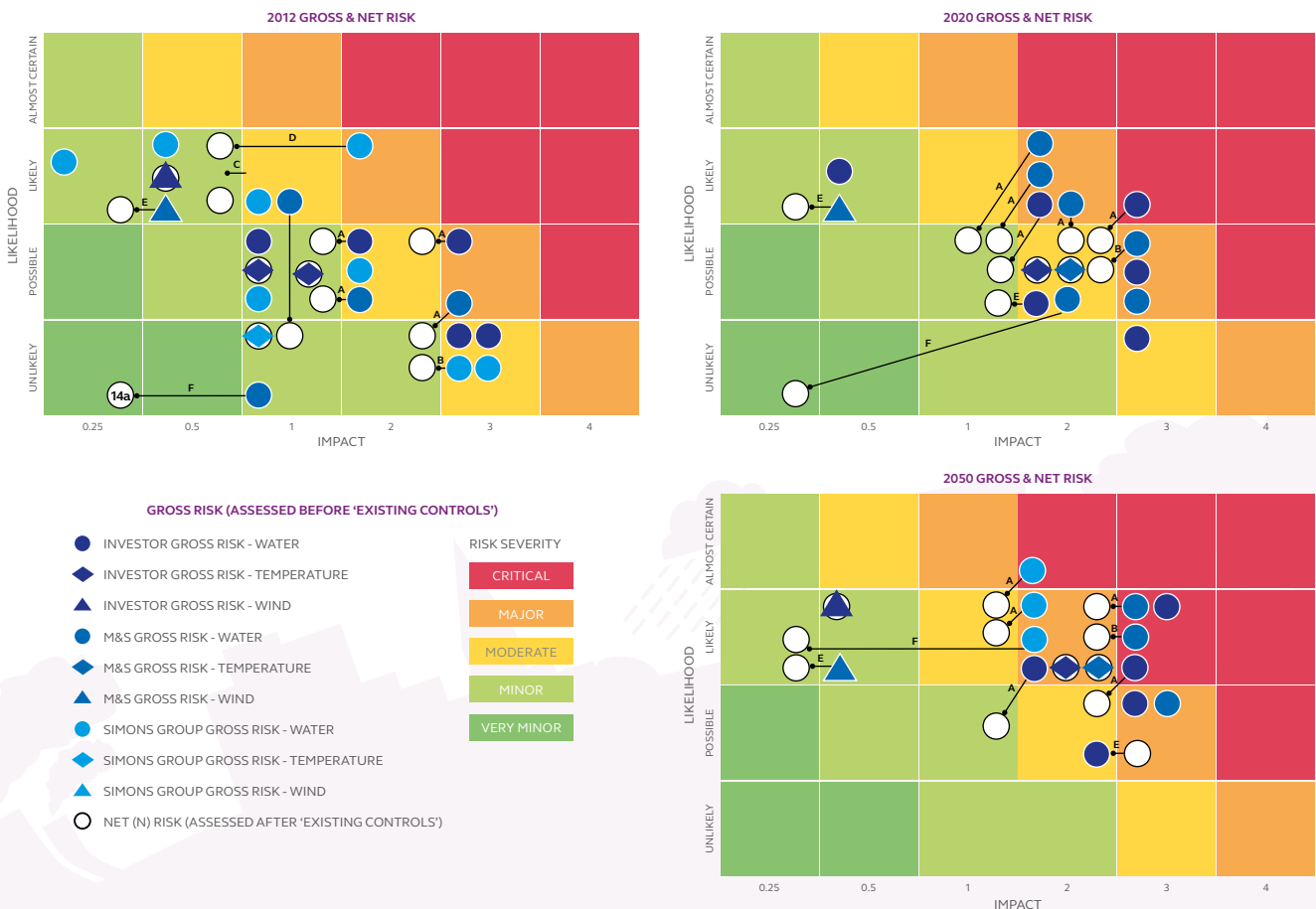
There is no prescribed standard for climate change risk assessment, but Bill Gething's adaptation matrices (see Appendix 3 of the full report) are nonetheless a useful basis for assessing buildings' vulnerability to and risks from climate change. Equally, the UK Climate Impacts Programme (UKCIP) Adaptation Wizard sets out a useful framework for building designers to develop adaptation strategies.

Adaptation demands skilful and specific communication, especially to engage the client, agree assumptions and metrics, to explain measures, and secure investment. Modelling is often necessary and can be carried out against baseline comparisons or with worst-case scenarios. The resulting data need to be carefully filtered and summarised before being presented to clients.

The concept of regret is important in the client's decision-making process, and should be taken into account by building designers. Options should be evaluated by reference to the UKCIP's decision-making framework, distinguishing no-regret, win-win, low-regret, under-adaptation and over-adaptation measures. Cost-benefit analysis, especially with whole-life costing, is important to help clients to decide on measures.







“The key deliverable from a climate change adaptation service is the phased adaptation plan.”

### Example of a stakeholder's needs assessment matrix



The Marks & Spencer Glandford Park Retail team used a simple matrix to assess financial stakeholders' needs (Deloitte)

# D4FC project case studies

	Name	Project team: <i>Client / Project lead</i>	Building type	Project description
	<b>COUNTY HALL, TROWBRIDGE WILTSHIRE</b>	<i>Wiltshire County Council</i> <b>WSP Built Ecology</b> Stride Treglown	<b>Offices</b>	Refurbishment of 1930s stone-construction four-storey listed building, with a 1970s concrete-framed extension
	<b>EXTRA CARE 4 EXETER</b>	<i>Exeter City Council</i> <b>Gale &amp; Snowdon</b> University of Exeter Jenkins Hansford Partnership	<b>Care home</b>	New-build care home on a brownfield site with 50 self-contained dwellings for elderly people and those with moderate dementia
	<b>GREAT ORMOND STREET HOSPITAL, PHASE 2B</b>	<i>Great Ormond Street Hospital</i> <b>WSP Built Ecology</b> Llewelyn Davies Yeang Gardiner & Theobald University College London	<b>Hospital</b>	New cardiac wing for children's hospital, converting existing concrete-framed building and adding a steel-framed seven-storey wing
	<b>UNIVERSITY OF SHEFFIELD ENGINEERING GRADUATE SCHOOL</b>	<i>University of Sheffield</i> <i>Graduate School</i> <b>Arup</b> Bond Bryan Architects Turner & Townsend	<b>University</b>	New university teaching space, including large lecture theatres, general teaching spaces, labs, facilities for postgraduate and doctorate work space, and offices
	<b>BRITISH TRIMMINGS EXTRA-CARE SCHEME, LEEK, STAFFORDSHIRE</b>	<i>Harvest Housing Group</i> <b>Triangle Architects</b> Leeds School of Architecture The Energy Council S I Sealy & Associates, SDA Consulting ABA Consulting	<b>Care home</b>	New-build development with 87 self-contained flats for elderly people with extra care needs
	<b>NORTH WEST CAMBRIDGE URBAN EXTENSION</b>	<i>University of Cambridge</i> <b>AECOM</b>	<b>Housing</b>	Masterplan for University of Cambridge land, including analysis of Urban Heat Island effect and summer overheating

	Name	Project team: <i>Client / Project lead</i>	Building type	Project description
	<b>CHURCH VIEW, DONCASTER</b>	<p><i>Doncaster Development Community Trust</i></p> <p><b>Bauman Lyons Architects</b></p> <p>Arup Herriot Watt University Oxford Brookes University Estell Warren Latz + Partners Bovis Lend Lease Creative Space Management</p>	<b>Office</b>	Refurbishment of an art college building in a conservation area to become multi occupancy serviced offices
	<b>HARASSING NANO-TECHNOLOGY TO COMBAT CLIMATE CHANGE, CENTRAL SAINT MARTINS, UNIVERSITY OF THE ARTS LONDON</b>	<p><i>Central Saint Martins College,</i></p> <p><b>University of the Arts</b></p> <p>Stanton Williams Atelier Ten Nanoforce Technology</p>	<b>University</b>	Redevelopment of Grade II-listed granary building into a new university campus, as part of King's Cross Central redevelopment
	<b>CLIMATE ADAPTATION PLAN, MARKS &amp; SPENCER</b>	<p><i>Marks &amp; Spencer</i></p> <p><b>Deloitte</b></p> <p>Simons Group Walker Institute</p>	<b>Retail</b>	Developing a climate adaptation plan for retail development using a new store at Glanford Retail Park, Scunthorpe, as a case study
	<b>PORTZED, BRIGHTON AND HOVE</b>	<p><b>BohoGreen</b></p> <p>APZED (Alan Philips Architects + ZEDFactory) Bobby Gilbert &amp; Associates Hemsley Orrell Partnership Monson Acoustic Associates Hayes Mackenzie</p>	<b>Housing</b>	Mixed-use seafront development
	<b>HARRIS ACADEMY, PURLEY</b>	<p><i>Harris Federation and London Borough of Croydon</i></p> <p><b>Aedas</b></p> <p>VZDV Consulting Engineers Wilmott Dixon</p>	<b>School</b>	4,000m <sup>2</sup> part-new-build, part-refurbishment school for 11-18-year-olds
	<b>WELLAND PRIMARY SCHOOL, PETERBOROUGH</b>	<p><i>Peterborough City Council Children's Services</i></p> <p><b>AECOM</b></p> <p>Kier Eastern Woods Hardwick Mott MacDonald ACD Landscape Architects Davis Langdon AECOM</p>	<b>School</b>	New single-storey school with natural ventilation



## D4FC project case studies







	Name	Project team: Client / Project lead	Building type	Project description
	<b>NEW ADMIRAL INSURANCE, CARDIFF</b>	<i>Admiral Insurance/Stoford</i> <b>BRE</b> Glenn Howells Architects Hoare Lea	<b>Offices</b>	90-year adaptation plan for new 1,860m <sup>2</sup> FTSE 100 headquarters
	<b>EDGE LANE: TIME PROJECT, LIVERPOOL</b>	<i>Liverpool and Sefton Health Partnership</i> <b>Medical Architecture and Art Projects</b> Low Carbon Building Research Group Oxford Brookes University Mott MacDonald Fulcrum Tony Danford Arup Camlin Lonsdale Davis Langdon AECOM	<b>Hospital/care home</b>	6,074m <sup>2</sup> new in-patient mental-health facility with 75 beds, on brownfield contaminated site
	<b>CARROW ROAD, NORWICH</b>	<i>Broadland Housing Association</i> <b>AECOM</b> Ingleton Wood University of East Anglia Sheils Flynn Rossi Long Consulting	<b>Housing</b>	£6m development of 46 flats above 150m <sup>2</sup> commercial space. Focus on overheating, keeping warm, stability, durability, water conservation, flooding, and drainage
	<b>THE CO-OPERATIVE HEAD OFFICE, MANCHESTER</b>	<i>The Cooperative Group</i> <b>Buro Happold</b> 3D Reid	<b>Office</b>	32,000m <sup>2</sup> new 15-storey office block. Focus on overheating, flooding and water stress
	<b>BETWS COLLIERY WASHERY, AMMANFORD, WALES</b>	<i>Quadrant Estates</i> <b>Kassanis + Thomas Ltd</b> Daedalus Environmental Davis Langdon CA Group Parkwood Consultancy Services/ RGA Waterman International (London)	<b>Housing</b>	£13m mixed-use development. Focus on overheating, durability, weather proofing and water stress

	Name	Project team: <i>Client / Project lead</i>	Building type	Project description
	<b>SITE J, NEW ENGLAND QUARTER, BRIGHTON</b>	<i>Hyde Housing Association Ltd</i> <b>3E</b> Yelo Philip Pank Partnership Mendick Waring Ltd	<b>Housing</b>	£25m mixed-use development including housing, hotel, retail and commercial. Focus on overheating, keeping warm, stability, durability, water conservation, flooding, and drainage
	<b>CLIFTONVILLE, MARGATE</b>	<b>Thanet District Council</b> Daedalus Studio Engleback WT Partnership SDA Architects Radius	<b>Housing</b>	£20m redevelopment scheme with refurbishment of Edwardian/Victorian houses in Margate to provide social housing. Focus on overheating, keeping warm, stability, weatherproofing, water conservation, drainage and flooding
	<b>ENVIRONMENTAL SUSTAINABILITY INSTITUTE, CORNWALL</b>	<b>The University of Exeter</b> Leadbitter Stride Treglown Method, Halcrow Group Cornwall Environmental Consultants Ward Williams Associates	<b>University</b>	£31.5m research facility arranged over three storeys in elevated position in Cornwall. Focus on overheating and durability
	<b>ST. FAITH'S SCHOOL MASTERPLAN, CAMBRIDGE</b>	<i>St. Faith's School</i> <b>Verve Architects</b> University of Cambridge Roger Parker Associates Andrew Firebrace Partnership The Huck Partnership Marston BDB	<b>School</b>	£5.4m refurbishment and new build school. Focus on overheating, water stress and durability.
	<b>TECHNICAL HUB @ EBI</b>	<b>AECOM</b>	<b>Offices</b>	New build laboratory research facility of 5,000m <sup>2</sup> .
	<b>EBBW VALE SCHOOL (11-16 PHASE)</b>	<b>BDP</b>	<b>School</b>	New secondary school – 9,890m <sup>2</sup> over 3 storeys in a former steelworks.

## D4FC project case studies


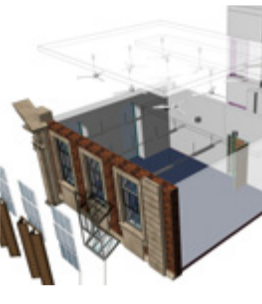
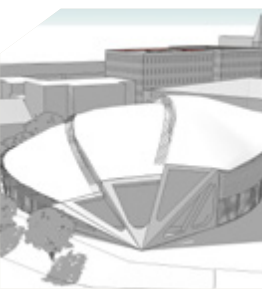

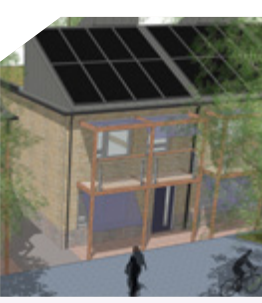

	Name	Project team: <i>Client / Project lead</i>	Building type	Project description
	<b>HARNESSING NANO-TECHNOLOGY</b>	Nanoforce Technology	<b>University Building</b>	£100k project looking at use of nanotechnology in responsive architecture as part of a Grade II granary refurbishment.
	<b>THE MILL IN CARDIFF</b>	White Design Associates	<b>Housing</b>	Mixed use 20 ha site with 900 homes, 30% affordable housing, 4,000m <sup>2</sup> offices, 500m <sup>2</sup> retail & 1,000m <sup>2</sup> community.
	<b>LONDON SCHOOL OF HYGIENE AND TROPICAL MEDICINE</b>	AECOM	<b>University building</b>	£10m refurbishment of Grade 2 building.
	<b>NW BICESTER ECO TOWN</b>	Hyder Consulting	<b>Housing</b>	Mixed use development delivering 5000 homes in 20 years plus facilities with 30% affordable.
	<b>OXFORD UNIVERSITY PRESS</b>	Hoare Lea	<b>Offices</b>	New build / refurb to provide 4,300 m <sup>2</sup> of space over 4 storeys.
	<b>NW CAMBRIDGE</b>	AECOM	<b>Housing</b>	Mixed use university complex over 15 years. Includes 3,000 accommodation units, a school, 100,000m <sup>2</sup> commercial.



	Name	Project team: <i>Client</i> / Project lead	Building type	Project description
	<b>100 CITY ROAD</b>	Arup	Offices	£76m development.
	<b>UNIVERSITY OF SHEFFIELD MAPPIN CAMPUS</b>	ARUP	University building	35,000m <sup>2</sup> new build and 40,000m <sup>2</sup> refurbishment.
	<b>C.A. TOOLKIT (M&amp;S)</b>	Deloitte	Retail	Refurbishment of 7,000m <sup>2</sup> retail unit.
	<b>ELLINGHAM PRIMARY SCHOOL</b>	ECD Architects	School	£8.8m new build
	<b>WYRE FOREST PRIMARY SCHOOLS</b>	Worcester County Council	School	Refurbishment of 5 primary schools.
	<b>ROYAL ACADEMY FOR DEAF, EXETER</b>	Skelly & Couch	School	School new build to provide residential education facilities over 3 storeys.






## D4FC project case studies


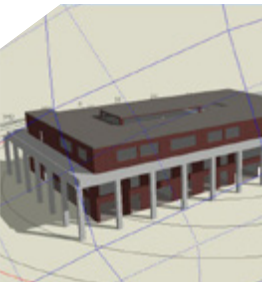


	Name	Project team: <i>Client / Project lead</i>	Building type	Project description
	<b>UNIVERSITY OF GREENWICH</b>	Hoare Lea	<b>University building</b>	17,000m <sup>2</sup> new build over 5 floors.
	<b>CORNWALL OFFICE RATIONALISATION</b>	Cornwall Council	<b>Offices</b>	Programme to reduce the number of workplaces and offices from 5,500 in 78 buildings to 3,500 in 30. 3 refurbished offices and 1 new.
	<b>PROJECT ANGEL</b>	Waterman Group plc	<b>Offices</b>	Regeneration project starting with a new 23,000m <sup>2</sup> office for the local authority
	<b>PASSIVOFFICES AT DEVONSHIRE GATE</b>	Gale & Snowden Architects Ltd	<b>Offices</b>	New development of 6,125m <sup>2</sup> office space.
	<b>QUEEN ELIZABETH II (QEII) HOSPITAL</b>	Penorye and Prasad LLP	<b>Hospital</b>	8,000m <sup>2</sup> hospital facility.
	<b>ONE GALLIONS - FUTURE CLIMATE : URBAN HOUSING</b>	Good Homes Alliance	<b>Housing</b>	High-density urban development arranged over 3 to 14-storey buildings.

	Name	Project team: <i>Client</i> / Project lead	Building type	Project description
	<b>DRAGON JUNIOR SCHOOL FOR THE FUTURE</b>	Ridge and Partners LLP	School	2,000m <sup>2</sup> school arranged over two storeys.
	<b>MANAGEMENT BEFORE FABRIC</b>	Bauman Lyons Architecture & Urbanism LLP	Museum	Refurbishment scheme
	<b>FUTURE SWIM 4 EXETER</b>	Exeter City Council	Swimming pool	£5.5m new pool and £1.5m 20 affordable housing units.
	<b>MASTERPLAN ST. FAITH'S SCHOOL, CAMBRIDGE</b>	St. Faith's School	School	Refurbishment and new build school.
	<b>PRINCES PARK, LIVERPOOL</b>	Triangle Architects Ltd	Housing	2,3 & 4 bedroom 116 unit social housing development.
	<b>CLIFTONVILLE</b>	Thanet District Council	Housing	Refurbishment of Edwardian / Victorian houses in Margate to provide social housing.



## D4FC project case studies

	Name	Project team: <i>Client</i> / Project lead	Building type	Project description
	<b>LONDON BRIDGE STATION REDEVELOPMENT</b>	WSP UK Limited	<b>Railway station</b>	Redevelopment and reconfiguration of Britain's 5th busiest station.
	<b>CARROW ROAD, NORWICH</b>	Broadland Housing Association Limited	<b>Housing</b>	Development of 46 flats above 150m <sup>2</sup> commercial space.
	<b>CLIMATE ADAPTIVE NEIGHBOUR- HOODS (CAN)</b>	Baca Architects	<b>Housing</b>	Mixed use development with 88 dwellings and 1350m <sup>2</sup> retail.
	<b>OAKHAM NORTH PHASE 1</b>	LDA Design Consulting LLP	<b>Housing</b>	135 house residential-led mixed use development.
	<b>ANDREW EWING PRIMARY SCHOOL</b>	WSP UK Limited	<b>School</b>	New school.
	<b>ACTON GARDENS</b>	AECOM	<b>Housing</b>	Mixed use development over 13-phase project led by delivering 2600 houses.

	Name	Project team: <i>Client</i> / Project lead	Building type	Project description
	<b>UNIVERSITY OF SALFORD</b>	Buro Happold	University	New build and refurbishment of 5 buildings.
	<b>ST PAUL'S RC SCHOOL LEICESTER</b>	Miller Construction (UK) Ltd	School	Refurbishment of 12,000m <sup>2</sup> school.
	<b>OCTAVIA HOUSING</b>	Octavia Housing	Housing	Social housing and new build.
	<b>HINGUAR PRIMARY SCHOOL, SHOEBURYNES</b>	Space Craft Architects Ltd	School	New school building.

## Preparing for an uncertain future

The concluding section of the report considers how adaptation services might become mainstream, identifying possible market and policy failures and summarising the case for intervention, including by central Government.

The D4FC programme sought to stimulate clients and designers to prepare the UK’s built environment for climate change by developing phased strategies for adapting new and existing buildings for the climate in 2030, 2050, or even 2080. Some of the funded projects were very successful in identifying adaptation measures which clients were willing to implement. Others were not.

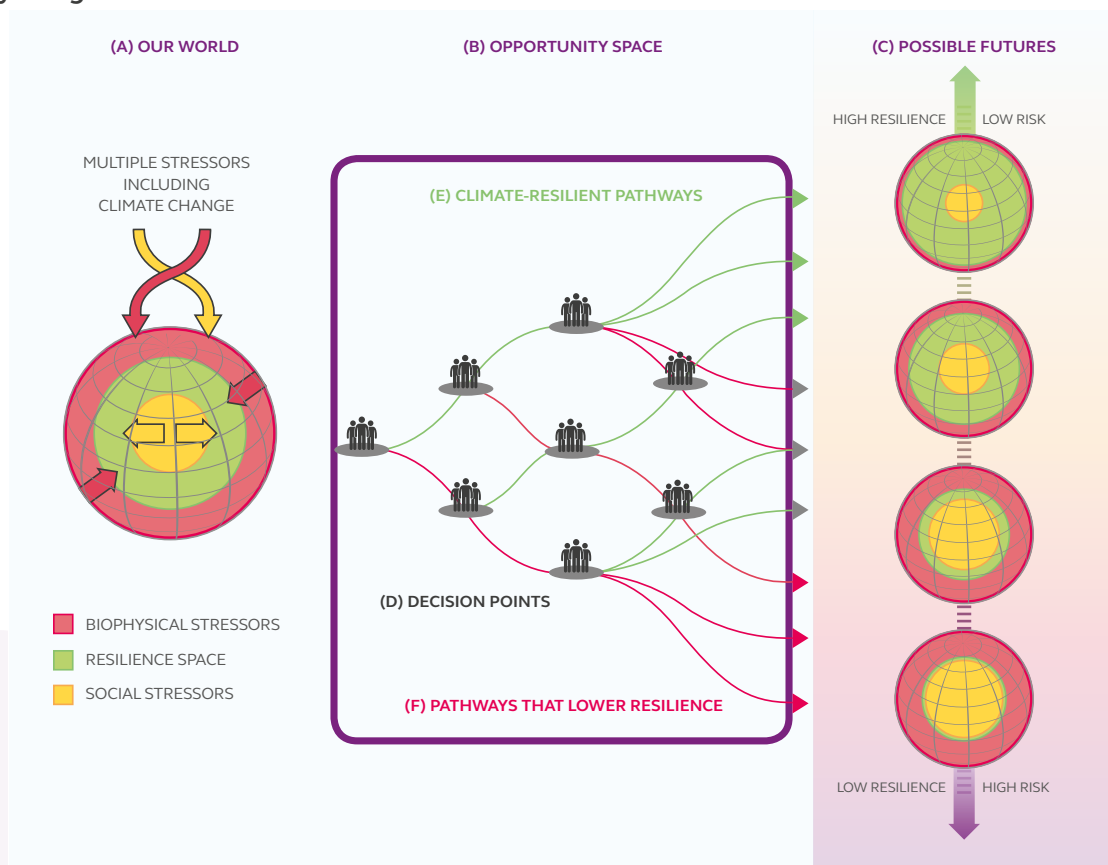
Across the country, the downside risks of not doing so are potentially severe and so the precautionary principle should apply. For example, the D4FC projects discovered that current Building Regulations and standards use historic climate data and, in a changing climate, are inevitably not fit for today’s climate, let alone what may come in the future.

The market for adaptation services is currently weak but the passage of time will improve it. However, left to market forces as recommended in current policy, adapting the UK’s built environment is likely to be reactive and possibly too late to avoid the downside risk. The existing barriers to creating a viable market for building design adaptation services constitute both market and policy failures, legitimate justifications for Government intervention.

The steps to creating the market – mainstreaming adaptation services – are to improve knowledge, leadership and policy. The effect on professional design fees is uncertain and depends on the potential to streamline adaptation to fit in with current practice. Innovators and early adopters are likely to benefit the most from the growth of the adaptation market.

“The market for adaptation services is weak but the passage of time will improve it.”

## IPCC’s opportunity space and climate-resilient pathways diagram

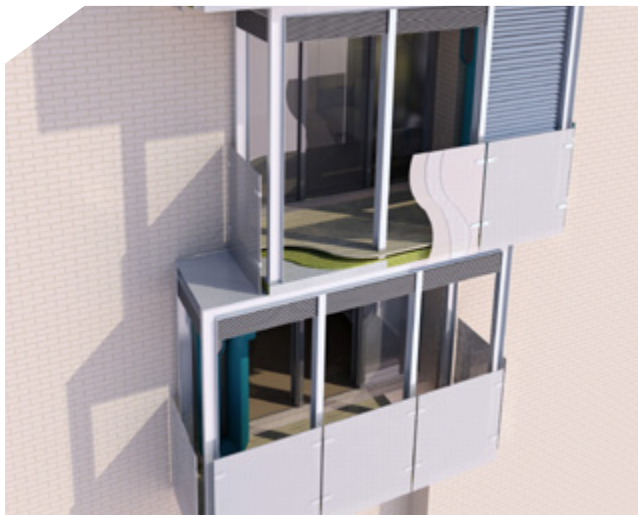


There is an opportunity cost in any delay to following green pathways, and the longer one delays, the less resilience is possible. If a significant proportion of the country’s building stock fails to be adapted in a planned way over time it is a matter for government intervention. (IPCC)

# About this report

## Purpose

This report is aimed mainly at building designers but also has sections that are directly relevant to construction clients and other stakeholders, and policy and regulation makers.



**D4FC:** New England Quarter, Brighton

It explores the emerging market for building design services to prepare buildings for a changing climate in the UK. It considers the following important questions:

- does preparing buildings for a changing climate make sense to construction clients?
- what kinds of clients are or ought to be interested?
- can building designers exploit the opportunity?
- what building design competences are needed?
- how can climate change adaptation be mainstreamed in the built environment?

Along the way, it highlights both the incentives to invest in climate change adaptation and the barriers to doing so. It summarises the steps needed to develop the market from its current innovation status to the mainstream.

## Evidence used

The evidence used for this report comes mainly from Innovate UK's £5m Design for Future Climate, Adapting Buildings (D4FC) programme, two subsequent targeted expert panel meetings, and a delegate questionnaire at Innovate UK's 'Building a Resilient Future' conference in February 2014.

The D4FC programme, now complete, aimed to improve the climate resilience of live building projects worth a combined capital value of £4.2bn. Fifty projects were funded – 26 in 2010, and a further 24 in 2011. Only buildings already targeting high standards of environmental performance were eligible. Those funded had to produce a final report documenting a phased and costed adaptation strategy on which clients could base effective decisions about what measures they needed to take over time<sup>7</sup>. Twenty-one of these final reports were singled out for in-depth consideration by the authors of this report<sup>8</sup> (the first 21 in the list starting on page 14) to reflect a broad range of geographical locations and client, procurement route and building types.

The expert panel meetings were convened by Innovate UK towards the end of 2013 and comprised people with varied expert knowledge – engineers, architects, consultants, client representatives – who had been involved in the D4FC projects<sup>9</sup>.

“We aimed to improve climate resilience in building projects worth £4.2bn.”

<sup>7</sup> All the final reports are freely available from <https://connect.innovateuk.org/web/design-for-future-climate/projects-outputs>

<sup>8</sup> These projects were selected because they contained useful material on the business case and business opportunities or because they were highlighted by Rachael Grinnell, who has carried out in-depth research into the Phase 1 projects as part of her PhD at Loughborough University. See <http://adaptablefutures.com>

<sup>9</sup> The first expert panel meeting focused on clients' business cases; the second focused on building designers' business opportunities. Audio recordings from both meetings were transcribed and are cited anonymously throughout this report. During the first meeting, the authors of this report asked panel members to fill out a questionnaire to explore client motivations. Since the respondents were mostly not client representatives but were asked to imagine how a real client of theirs would answer, the results (see INSERT URL) must be treated accordingly. A later questionnaire asked delegates at the final D4FC conference in 2014 to rate four statements on a Likert scale to validate some of the conclusions of this report. The findings can be found here <https://connect.innovateuk.org/web/design-for-future-climate/documents>



## Scope

**This report principally considers the built environment at the scale of individual buildings, new and existing. It touches on issues affecting the larger masterplan and neighbourhood scales but, because they overlap with local and national policy, these scales are not the focus here. The report also specifically excludes infrastructure from its scope, for the same reason.**

It builds on five published outputs to disseminate learning from the D4FC programme:

- *Design for Future Climate: Opportunities for adaptation in the built environment* by Bill Gething (Innovate UK)
- *Design for Climate Change*, by Bill Gething and Katie Puckett (RIBA Publishing)
- *Climate Change Adaptation in the UK Built Environment Climate Change Adaptation Survey: Results* (Modern Built Environment Knowledge Transfer Network on behalf of the Environment Agency Climate Ready Support Service)
- *Guidance for making the case for climate change adaptation in the built environment* (Modern Built Environment Knowledge Transfer Network on behalf of the Environment Agency Climate Ready Support Service).

## National policy context

**There is widespread recognition that there need to be both regional and sectoral action plans for tackling climate change adaptation. Governments have played an enabling role, ensuring that frameworks are in place to monitor states of preparedness and that key information – such as that from the D4FC programme – is available and accessible<sup>10</sup>.**

In the UK, for example, the Government initiated a cascade of programmes aimed at meeting the challenge in a robust and systematic way, underpinned by several key pieces of legislation, including the Climate Change Act (2008)<sup>11</sup>. This culminated in DEFRA's 2013 National Adaptation Programme (NAP)<sup>12</sup>, which identifies the built environment as one of its key areas of focus. Part of its vision is that:

“Buildings and places, and the people who live and work in them, are resilient to a changing climate and extreme weather, and organisations in the built environment sector have an increased capacity to address the risks and take the opportunities from climate change.”

However, to achieve this vision it recognises that there is work to be done, including the need to:

- implement priority actions to increase the level of skills and training in the built environment sector
- disseminate learning from Innovate UK's D4FC competition
- develop guidance on making a business case for climate change adaptation.

This report responds to these needs.

<sup>10</sup> Øystein Hov, U. C. (2013). *Extreme Weather Events in Europe: preparing for climate change adaptation*. Norwegian Meteorological Institute.

<sup>11</sup> HM Government. (2008). *Climate Change Act*. London: HM Government. Others include Flood and Water Management Act (2010), Civil Contingencies Act (2004), Water Framework Directive (2000), Localism Act (2011), Planning and Compulsory Purchase Act (2004), and the Marine and Coastal Access Act (2009). However, none regulates the activities of building designers in detail.

<sup>12</sup> DEFRA. (2013). *National Adaptation Programme: Making the country resilient to a changing climate*. London: HM Government.

## About this report

### Underlying assumptions

#### Climate change is happening

**While the state of future climate science is correctly characterised by uncertainty, there is an overwhelming consensus from climate models about the direction of change.**

In their *Summary for Policymakers: the Physical Science Basis (Working Group 1, Fifth Assessment Report)* (2013)<sup>13</sup>, the Intergovernmental Panel on Climate Change (IPCC) says:

“Continued emissions of greenhouse gases will cause further warming and changes in all components of the climate system.”

Equally, historical trends in climate averages globally support the assumption.

“Continued emissions of greenhouse gases will cause further warming and climate change.”

“Globally there has been a threefold increase in loss-related floods since 1980.”

#### Some climate change is inevitable

**There is a consensus now that some climate change has already occurred and that even if we cut emissions immediately to zero, the momentum in the climate system would continue to drive change. The IPCC’s Summary for Policymakers says:**

“Most aspects of climate change will persist for many centuries even if emissions of CO<sub>2</sub> are stopped. This represents a substantial multi-century climate change commitment created by past, present and future emissions of CO<sub>2</sub>.”

There is also a marked upward trend in the frequency of severe weather events globally. Referring to the dramatic flooding in southern England at the start of 2014, Nicholas Stern, author of the influential *Stern Review on the Economics of Climate Change* (2006), wrote on the front page of the *Guardian*<sup>14</sup>:

“The record rainfall and storm surges that have brought flooding across the UK are a clear sign that we are already experiencing the impacts of climate change.”

These are accompanied by increases in weather-related insurance losses, many of them associated with damage to or the failure of built assets. Insurance company Munich Re’s natural catastrophe database, the most comprehensive of its kind in the world, shows a marked increase in the number of extreme weather-related events. Its website<sup>15</sup> reported:

“Globally there has been a more than threefold increase in loss-related floods since 1980 and more than double the number of windstorm natural catastrophes, with particularly heavy losses as a result of Atlantic hurricanes.”

<sup>13</sup> Intergovernmental Panel on Climate Change. (2013). Summary for Policymakers. In IPCC, & T. D.-K. Stocker (Ed.), *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.

<sup>14</sup> Stern, N. (2014, February 14). *Climate Change is here now. It could lead to global conflict. Yet the Politicians squabble*. London: The Guardian.

<sup>15</sup> Munich Re. (2010, September 27). Large number of weather extremes as strong indication of climate change. Retrieved from [www.munichre.com: www.munichre.com/en/media-relations/publications/press-releases/2010/2010-09-27-press-release/index.html](http://www.munichre.com: www.munichre.com/en/media-relations/publications/press-releases/2010/2010-09-27-press-release/index.html)

### Adaptation is linked to mitigation

**The IPCC is now almost unequivocal that climate change is caused by anthropogenic global warming. Its Summary for Policymakers: the Physical Science Basis (Working Group 1, Fifth Assessment Report) says:**

“It is extremely likely (i.e. 95% certain) that human influence has been the dominant cause of the observed warming since the mid-20th century.”

It follows, therefore, that adapting to climate change must not compromise efforts to mitigate it. As the *World Economic Forum’s Global Risks 2013* report<sup>16</sup> puts it:

“The less effective mitigation efforts are, the more pronounced adaptation challenges will become; therefore, mitigation and adaptation need to be addressed in concert while taking advantage of all possible synergies.”

#### The link between adaptation and mitigation

Adaptation and mitigation are inextricably linked, with the risk that responding to the adaptation agenda can be at the expense of mitigation and vice versa, compounding the problem in an escalating spiral of increasingly damaging impacts. The clearest example of this would be to base an adaptation strategy on an increased use of fossil-fuelled energy, or a mitigation strategy that increases the building’s vulnerability to climate change.

It is also likely that energy will become increasingly expensive for the foreseeable future and perhaps in shorter supply.

### Adaptation is needed

**The National Adaptation Programme confirms that there is a need to prepare the UK’s built environment to cope with the changes.**

It is clear that these changes will have a significant impact on buildings, whose longevity – typically 60 years or more – guarantees that the weather they encounter in the middle, let alone at the end, of their lives will be very different to that at the start.

Since climate change is a moving target – there is no one future but many, dependent in part on the success of mitigation efforts – the technical challenge is not to design

or retrofit buildings for now or then. Instead, the challenge is how to optimise the design now for the most effective phased transition to what may be needed in the future.

However, some parts of buildings – such as their location, orientation, foundations, ceiling heights, and so on – cannot easily or viably be adjusted in maintenance cycles but are nonetheless fundamental to a building’s ability to cope with these possible future climates. If these immovable features cannot cope, the building risks becoming a ‘stranded asset’.

The need for a phased approach is determined by economic and financial considerations as well as uncertainty around the speed and magnitude of change. Even if it were affordable, building in all the features that would protect a building, its owners, occupants and contents from day one is unnecessarily wasteful, could close down opportunities to exploit future technological advances, and could compromise efforts to mitigate climate change. As the final report for Betws Washery, a D4FC project, noted:

“If all the adaptations are adopted it would add nearly £1.5m to the capital cost of the project, increasing it from an estimated £14.85m to £16.3m (10%). This is too large a step to even consider trying to justify.”

### Adaptation is urgent

**Finally, as the IPCC’s Summary for Policymakers makes plain, the need to adapt to climate change is pressing. Even looked at, as we do in this report, from the blinkered perspective of just the built environment, the UK’s buildings are facing significant threats.**

Not only are economic losses from extreme weather events on the increase, the proven negative impacts from overheating – loss of productivity in the office, ill health and even death among vulnerable people – could rise. Clearly, building designers and their clients have an important role to play in minimising these and many other threats. The urgency is compounded by current design practice that uses historic measured data which, in a changing climate, is necessarily out of date.

“Current design practice uses historic and out-of-date climate data.”

<sup>16</sup> World Economic Forum. (2013). *Global Risks 2013 Executive Summary*. Geneva: World Economic Forum.

# 1 Background



**Almost every part of society and the economy is at risk from climate change, from food production, to human health, biodiversity, infrastructure and buildings.**

These risks are acknowledged by two authorities not known for their hyperbole. In its Global Risks 2013<sup>17</sup> executive summary, the World Economic Forum framed the risks as follows:

“Future simultaneous shocks to both the global economic and Earth’s environmental systems could trigger the ‘perfect global storm’, with potentially insurmountable consequences ... On the environmental front, the Earth’s resilience is being tested by rising global temperatures and extreme weather events that are likely to become more frequent and severe.”

In the same document, *Nature* magazine identified climate change as an “emerging game-changer”. It highlighted runaway climate change, saying:

“It is possible that we have already passed a point of no return and that Earth’s atmosphere is tipping rapidly into an inhospitable state.”

## Impacts on the built environment

The background primer, *Design for Future Climate*<sup>18</sup>, produced for Innovate UK to support teams bidding for and engaged in the D4FC programme, identified three broad categories of risk to buildings from future climate change in the UK. They are:

- risks that affect comfort and energy performance – warmer winters may reduce the need for heating, but keeping cool in summer without increasing energy use and carbon emissions will present a challenge
- risks that affect construction – resistance to extreme conditions, detailing, and the behaviour of materials
- risks in managing water – both too much (flooding) and too little (shortages and soil movement).

These distinctions have proved helpful, and formed the backbone of the approach taken subsequently by designers taking part in the D4FC programme. However, the notion of ‘comfort’ as understood by building design professionals ought to be widened to include occupant health and wellbeing.

<sup>17</sup> World Economic Forum. (2013). *Global Risks 2013 Executive Summary*. Geneva: World Economic Forum.

<sup>18</sup> Gething, W. (2010). *Design for Future Climate: Opportunities for adaptation in the built environment*. Swindon: Innovate UK



## The language of risk

(Adapted from *Language of Risk - Project Definitions; and Management Methodologies*<sup>19</sup>)

Because risks, hazards, and vulnerabilities are complex, the terms have no precise definition. This is an acknowledged source of confusion. Most important is the distinction between ‘hazard’ and ‘risk’, best clarified by reference to the commonly adopted Source-Pathway-Receptor-Consequence model.

Very simply, **risk** in this model is the **likelihood** of the **hazard** multiplied by its **consequence** – see figure below.

For a risk to arise there must be a hazard that consists of:

- a **source** or initiator event (for example, high rainfall)
- a **pathway** between the source and the receptor (for example, flood routes over land)
- a **receptor** (for example, a building).

The likelihood of climate change hazards resulting from climate change can be explored using data derived from the UKCP09<sup>20</sup>. Likelihood is composed of:

- **probability** – for example, the chance of a specific temperature occurring compared to the total population of temperatures – and
- **frequency** – the number of times that temperature will occur in a given timeframe.

Consequences are good or bad economic, social or environmental impacts that can be measured quantitatively – ‘damages will cost £3m’ - or qualitatively – ‘its impact will be low’.

This overview is simplistic. First identifying risks and then drawing useful conclusions from them is multi-dimensional, involving a mix of quantified data and guesswork.



<sup>19</sup> HR Wallingford. (2011). *Language of Risk - Project Definitions; and Management Methodologies*. London: Greater London Authority.

<sup>20</sup> In the UK, climate projections are produced by the Met Office Hadley Centre and are known as UKCP09 (UK Climate Projections 2009). See Appendix 3.

## Background

### The consequences of climate change: opportunities and threats

Climate change brings opportunities as well as threats. For example, warmer winters will reduce the overall need for heating during winter, bringing significant reductions in greenhouse gas emissions and cheaper average winter energy bills.

However, the threats cannot be ignored. The same trends that reduce energy demand in winter may increase it in the summer as cooling loads increase, demonstrating again the close relationship between adaptation and mitigation.

While the opportunities are important and should not be overlooked, the threats are the focus of concern in the adaptation challenge for building designers. This is because buildings are often seen as playing a more prominent role in mediating threats than they do in helping users to exploit opportunities. The most important threats are loss of life followed by economic losses, usually from severe weather events. These are the two that tend to be reflected in dramatic headlines and staggering economic loss statistics.

“The 2003 UK heatwave caused 2,000 deaths.”

### Climate change threats: loss of life

Extreme weather events have been responsible for considerable loss of life in Europe, estimated at around 140,000 since 1980 – averaging at 4,000 a year from a population of 730m, an important (but tiny) fraction. Most deaths have come from heatwaves<sup>21</sup>. Two thousand people died in the UK as a result of the 2003 heatwave, a weather event that could become the norm by the end of the century<sup>22</sup>.

Again, although this is tiny in comparison to the numbers of deaths attributed to winter weather, the figure is nonetheless significant. As the Heatwave Plan for England – 2013<sup>23</sup>, drawn up as a consequence of the 2003 event, says:

‘At-risk groups include older people, the very young and people with pre-existing medical conditions as well as those whose health, housing or economic circumstances put them at greater risk of harm from very hot weather.’

It is clear that the performance of buildings plays a role in mediating these losses. The heatwave plan identifies several high-risk factors, including ‘living in urban areas and south-facing top-floor flats’ and ‘activities or jobs that are in hot places or outdoors and include high levels of physical exertion’. The association between climate change hazards and the occupants of buildings was recognised by many of the D4FC projects. For example, the final report for the Extra Care for Exeter project says:

“The intrinsic nature of the extra care facilities’ occupants, being elderly and likely to be on medication, with cases of moderate to high levels of dementia, put this user group into the highest levels of overheating risk exposure in warming climates. The nature of the occupants also makes them more vulnerable to additional effects of climate change other than overheating and heat stress such as contaminants and pollutants, causing further health problems. In addition, most of the occupants will rarely leave the building and will be staying in the building continually during extreme heatwaves.”

<sup>21</sup> Øystein Hov, U. C. (2013). *Extreme Weather Events in Europe: preparing for climate change adaptation*. Norwegian Meteorological Institute.

<sup>22</sup> Carbon Disclosure Project. (2012). *Insights into Climate Change Adaptation by UK Companies*. London: DEFRA.

<sup>23</sup> Met Office and the Local Government Association. (2013). *Heatwave Plan for England 2013 - Protecting health and reducing harm from severe heat and heatwaves*. Met Office and the Local Government Association.

## Climate change threats: economic losses

**Economic losses in Europe have been considerable, costing an estimated €415bn since 1980 (2010 values). The most costly hazards have been storms and floods, amounting to a combined total of almost €300bn<sup>24</sup>.**

In the UK in 2010, insured losses from weather-related events cost an average of £1.5bn each year. The summer floods of 2007 in central England cost the economy over £3bn<sup>25</sup>. In their *The Financial Risks of Climate Change* (2009) report, the Association of British Insurers said:

“The insured cost of extreme flood losses occurring on average once every 100 years in Great Britain could rise by 30% to £5.4bn. The costs of windstorms occurring on average once every 100 years could rise by 14% to £7.3bn.”

Again, it is clear that many of these losses are associated with impacts on buildings and that they do not just reflect increases in the value of assets.

“The 2007 summer floods in England cost more than £3bn.”

## Climate change threats: the effect of temperature rise

**There are other less headline-grabbing risks that nonetheless could have a dramatic cumulative effect. Many of them arise from projected increases in temperature. The UK Climate Change Risk Assessment (CCRA) highlights overheating and cooling energy demand as medium consequence risks in the short-to-medium term (2020-2050s), and high consequence risks in the long term (2080s).**

In fact, a study by the Chartered Institution of Building Services Engineers and Arup found that many existing buildings were already failing to meet comfort criteria of not exceeding 28°C for more than 1% of occupied hours<sup>26</sup>. Indeed, other studies go further, revealing a mismatch between design standards and occupant perception, so that even where criteria are met, occupants are still uncomfortable<sup>27,28</sup>. If that’s the situation now, how much worse will the effect become over time, and how damaging will it be to clients and their buildings’ stakeholders?

Overheating affects intellectual performance. For example, a 1999 study of employee productivity identified comfort as one of the ‘killer’ variables for productivity in the workplace, with productivity losses of up to 20% associated with declining levels of comfort<sup>29</sup>. PwC UK’s *Is UK Plc climate-ready?* (2013) report identifies this risk too, quoting a ‘potential loss of staff hours due to high internal building temperatures’<sup>30</sup>.

<sup>24</sup> Øystein Hov, U. C. (2013). *Extreme Weather Events in Europe: preparing for climate change adaptation*. Norwegian Meteorological Institute.

<sup>25</sup> Carbon Disclosure Project. (2012). *Insights into Climate Change Adaptation by UK Companies*. London: DEFRA.

<sup>26</sup> Hacker, J. B. (2005). *Beating the Heat: Keeping UK buildings cool in a warming climate*. Oxford: UKCIP.

<sup>27</sup> Nicol, A. M. (2013, April 10). *Overheating in Schools: comparing existing and new guidelines*. *Building Research & Information*, 41(3), pp. 317-329.

<sup>28</sup> Despoina Teli, M. J. (2011). *Overheating Risk Evaluation of School Classrooms*. *World Renewable Energy Congress 2011* (pp. 1821-1828). Linköping: Low Energy Architecture.

<sup>29</sup> Leaman, A. B. (1999). *Productivity in buildings: the killer variables*. *Building Research and Information*, 27(1), 4-19.

<sup>30</sup> Interestingly, evidence shows that humans can tolerate higher temperatures if, for example, that is what they are used to. Called ‘adaptive thermal comfort’, the concept is now incorporated into the American Society of Heating, Refrigeration, and Air-Conditioning Engineers’ (ASHRAE) Standard 55, and in CIBSE’s forthcoming *Guide A: Environmental Design*. Several of the D4FC projects adopted this model although how successfully they sold it to their clients is unclear.

## Background



### Climate change threats: increases in energy demand

**A possible consequence of projected temperature rises in unadapted buildings is the increased uptake and use of air cooling systems.**

The Analytical Annex to the Government's National Adaptation Programme calculates that if this uptake continues at today's rate to 2050 so that around 1% of London households have cooling (compared with 0.6% in 2010), energy demand for cooling could triple between 2010 and 2050 in London. However, if by 2050 half of the households in London had air conditioning, energy demand for cooling could be around 37 times higher in 2050. The carbon cost of this and the strain on the nation's electricity generating capacity and power distribution infrastructure as people switch from gas are unlikely to concern an individual construction client. However, interruptions in supply or its cumulative upward effect on the price of energy most probably will.

## Climate risk is just one of many

**It is impossible to think of climate change risks in isolation from all the other issues affecting building design, such as structural integrity, aesthetic appeal, the M&E strategy or changes in technology. All must be choreographed simultaneously for a satisfying result, which is an extraordinarily complex interconnected process requiring compromises and trade-offs along the way.**

Overlaying climate change adaptation on that already complex picture — especially when it is not mandatory and rarely asked for by the client — is difficult and creates a tension in professional practice. Competitive fees necessarily limit design time and resources and designers need to concentrate their efforts for maximum return.

Three factors must be gauged:

1. To what extent is the proposed **building** likely to benefit from adaptation? This is covered in Appendix 5.
2. To what extent is the **client** likely to be interested in adaptation? There are many different kinds of client, all differently motivated and so more or less likely to be interested in adaptation. This is covered in Section 2.
3. To what extent is the **building designer** and team able to design for adaptation? It is not just the designer's competence and skill that matters here – it is the size of their organisation, its strategic approach to business, and its market positioning. This is covered in the Section 3.



## Complexity and uncertainty

Because climate projections are by definition based on weather averages (typically over a 30 year period), the inherent variability of weather and near extreme conditions that define design criteria are smoothed out, masking critical impacts for buildings. For example, high average rainfall in itself might not present a problem to a building. The crucial design challenge is how it copes with a high-intensity short burst of rain which can overwhelm a rainwater system and cause a flood.

So, while averages are useful for exposing trends, they do not provide the granularity needed to analyse how buildings behave in response to typical weather patterns or the near extreme conditions used to test designs.

For this reason, the information supplied in the UK's climate projections<sup>32</sup> (known as UKCP09 – see Appendix 3) cannot be used directly by building designers. UKCP09 includes a Weather Generator<sup>33</sup>, a specialist tool with high computational overheads that provides a means to bridge the gap to some extent, including the generation of standard future weather files that can be used with industry-standard thermal simulation modelling software to analyse building performance.

To use future climate data in any form, building designers are faced with choosing between different scenarios, temporal periods and where on the probabilistic range to position design criteria for any given bit of analysis, potentially with different combinations applying to different aspects of the design.

This highlights two characteristics that are fundamental to the business case for adaptation in the built environment.

### Complexity

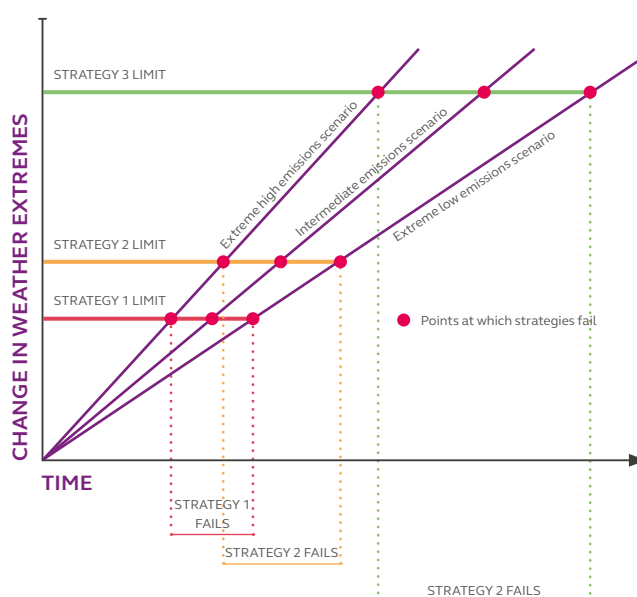
**The first is complexity. Designers need to become familiar with the probabilistic format of future climate data and are faced with a daunting range of combinations of parameters to consider when deciding on design criteria to use to explore the impacts of climate change on a building design.**

To the extent that it is possible to do so, this complexity must be understood if we are to respond effectively to the challenges.

### Uncertainty

**Second, uncertainty obstructs action on adaptation. The projections are inherently uncertain, based on climate models that are imperfect, using notional emissions scenarios that have been selected simply as a representative range of patterns of possible future emissions.**

The statistical approach taken by UKCP09 to incorporate results from a range of plausible climate models adds statistical robustness but their presentation as probabilistic ranges is unfamiliar to non-experts and difficult to explain to clients.



**GRAPHIC 1: The effect of uncertainty on adaptation strategies.**

Adaptation Strategies 1, 2 and 3 are progressively more able to withstand extremes of weather. It is not possible to be precise about when Adaptation Strategy 1 might fail, already making it difficult to plan for. The effect is greatly compounded in Strategy 3.

As Graphic 1 shows, justifying investment on the basis of what will happen in the future, when, and how severely, is necessarily challenging. However, this complexity and its attendant uncertainty are not excuses for not acting.

<sup>32</sup> See <http://www.metoffice.gov.uk/services/climate-services/uk/ukcp>

<sup>33</sup> See <http://ukclimateprojections.metoffice.gov.uk/23261>

# 2 Business case and client profile

## The business case for adaptation

**Clients are unlikely to regard climate change adaptation in isolation from the overall design effort. Even if they are extremely motivated to do so, concentrating on adaptation in the context of the total number of other issues – some seen as being of much more immediate importance – is likely stretch their resources.**

This section analyses the factors involved and distils rules of thumb to help building designers to profile whether clients are likely to be interested in thinking about investing in adaptation design services.

There are many kinds of client for building design services, distinguished by their fundamental purpose, the duration of their stake in the building, their attitude to risk, and a myriad of other increasingly subtle factors. However, despite these differences, almost all share one overriding concern – capital cost. Before clients will invest in a new building or in upgrading an existing one, they need to be convinced that:

- the return on their investment, however that is calculated, is worthwhile.
- the money could not be spent more effectively elsewhere; and
- the project is aligned to their fundamental purpose;

All clients need the best return on investment, calculated more or less formally as how much better the money will do – however that is calculated – over time (the internal rate of return) than leaving it in the bank (the net present value - NPV).

The key factor affecting decisions to invest in adaptation here is time. A client (such as a developer) who sells the building immediately on completion will typically define return on investment purely in terms of financial profit on the sale. Since profit is their fundamental purpose, the only responsible reason to adapt (in the absence of any regulated obligation or risk to reputation) would be to boost the immediate bottom line. This can be hard for building designers to sell to developers when the chief benefit of adaptation services is adaptive capacity (see adaptive capacity text box on page 37), only felt directly some years into the future by new owners.

“It is difficult to invest in systems that require high additional capital investment because, whereas these may theoretically be ‘paid back’ through cost savings, the initial capital cost is borne by the developer whilst the tenant/occupier receives the on-going benefit”  
(Central Saint Martins College report)

And because new owners and end-users are not yet demanding it, adaptive capacity has little impact on the saleability of a building. As a client contributor to the expert panel said:

“The housebuilder mentality is, ‘Is there a risk that I can’t sell it?’ Very unlikely.”

“It is difficult to invest in systems that require high additional capital investment.”

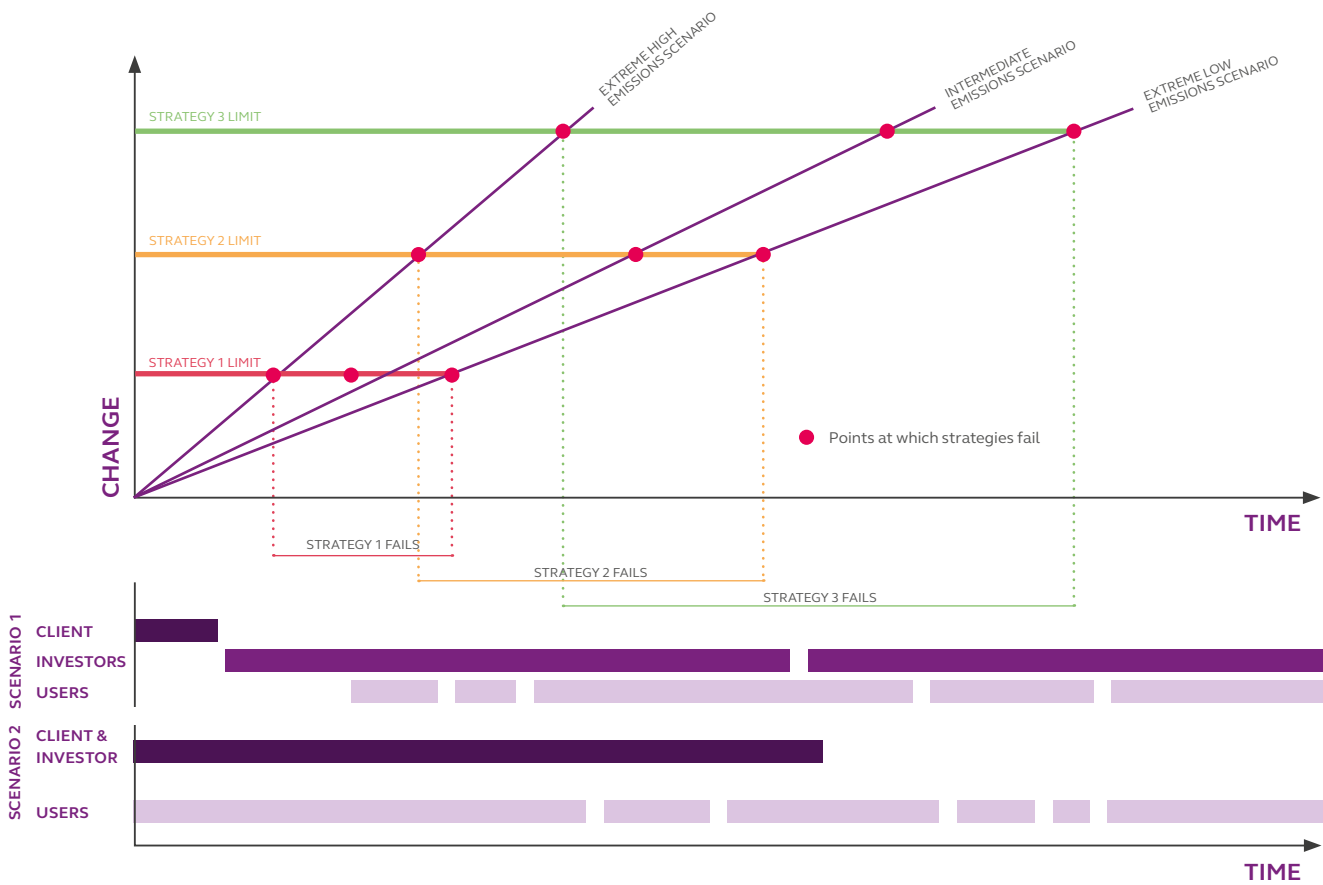
### D4FC projects in context

Clients and design teams working on D4FC projects – all of which already had high environmental aspirations – were funded to give close attention to adaptation. This work was entirely supported by Innovate UK and so many of the normal commercial constraints on the level of scrutiny possible were thus obviated. Despite this, the adaptation work was often run as a parallel work stream

unrelated to the key project drivers, sometimes by different teams not simply made up of building designers, and their carefully considered recommendations were sometimes turned down (generally because they were deemed not cost-effective or were recommended too late in the process).

This is not to say that, given the natural variability of weather and the increasing occurrence of extreme events, conditions that demonstrate the vulnerability of the building do not occur before the sale can be made. There are a number of examples where the 2014 flooding will have severely reduced the value of buildings and sites affected by it.

“The 2014 flooding will have severely reduced the value of buildings affected by it.”



**GRAPHIC 2: The interests of different stakeholders over time.** This chart elaborates Graphic 1, adding time-lines showing the interests the different stakeholders have through the life of the building for two different notional stakeholder scenarios.

In Scenario 1 the client commissioning the building has very little incentive to commission adaptation strategies because they will already have sold on their interest in the building before climate change has had a significant effect. The initial investor has a longer term interest and will need to consider the effect of climate change when it comes to selling their asset eventually. The users are a further stage removed with relatively short-term interests but will be in a position to judge how well the building is able to meet their needs as compared with alternative properties at the point in time when they are looking for premises.

Scenario 2 shows a situation where the client commissioning the building has an enduring interest – a registered social landlord, for example. They are more likely to be concerned about adaptation because they have a direct need to consider the needs of the users of their buildings over an extended period. They will need to consider long-term strategies, perhaps introduced sequentially as conditions change and the evidence for future change strengthens.

## Business case and client profile

### When to adapt?

**There is no point in investing in climate change adaptation earlier than necessary, which emphasises the good sense of a phased plan that delays measures until they are closer to being needed. However, the uncertainty in both the timing and intensity of future weather impacts for clients' buildings inhibits their motivation even to commission professional adaptation services to produce such a plan. As an expert panel member said:**

“The climate isn't going to change from one day to the next. That's the issue with these changes. They are erratically incremental, which makes them even harder to respond to.”

Big news stories about cataclysmic storms, heatwaves or flooding raise climate change in the national consciousness, and direct experience of the consequences brings it home more strongly still. On top of that, general education by reading reports like this or from knowledgeable, competent building designers will clearly help.

However, none of these factors are likely to trigger relevant investment in design services or capital expenditure unless clients are persuaded that the changing climate is a risk to their buildings. To add to the complexity, different hazards will manifest at different times, affecting the various elements of buildings differentially, and some of these elements can be adjusted in response more easily than others.



**Rule of thumb: the business case for adaptation becomes stronger with more certainty of future risk.**





### Adaptive capacity: planned upgrades, reactive triggers, and timing

In talking about climate change impacts on the national economy, the National Adaptation Programme's Analytical Annex<sup>34</sup> regards adaptive capacity as a prime strategy for 'allocative efficiency', or using resources over time in the most efficient way.

Long-lived, hard-to-alter and hard-to-replace aspects of buildings – location, form, orientation, foundations, glazing ratio, ceiling heights, and so on – must be designed to be able to cope with the weather conditions they will encounter at the ends of their lives. Thus, they must be in place from day one for optimum allocative efficiency.

Although closely interlinked with the longer lived ones, many other elements do not last the life of the building. Instead, they are designed to be maintained, altered or replaced at intervals during the building's life. This presents an opportunity to upgrade their performance only as needed, coincidentally making it possible to take advantage of improved future technological advances and to reassess the severity and speed of climate change. They need merely have the capacity to adapt, and so a schedule for when and how – called the phased adaptation plan in this report – is key to any adaptation strategy.

The timing of upgrades is hard to predict. Linking risk management to the maintenance cycle was a strategy used by many of the D4FC projects to avoid having to respond reactively to events, particularly where the client had an ongoing interest in the building. In this way, it will be possible to reassess needs when maintenance is due – evidence will have built up, the base position will have changed, and projections will have been updated.

For example, the Environmental Sustainability Institute team classified some of their measures in relation to

timing, a system that implies that climate change risks will be continuously monitored.

- 1. Must be implemented now:** measures that are either impossible or too expensive/disruptive to be implemented retrospectively.
- 2. Can be implemented at replacement/ refurbishment periods:** measures implemented as building components and systems are replaced over the building's life.
- 3. No trigger point as such – behaviour measure:** measures that can be implemented at any time at no capital cost by promoting different behaviours in building users.
- 4. No trigger point as such – capital measure:** measures that can be retrospectively applied, at a cost, at any time, reactively and independent of any other activity in the building.

As part of its recommended strategy, the Glanford Retail Park final report<sup>35</sup> classifies measures in roughly the same way. They went further, however, identifying five key reactive triggers that would spark greater investment in responding to climate risk.

- 1. Changes to insurance cover**
- 2. Legal obligation or the assignment of negligence to un-adapted developments**
- 3. Cost of adaptation initiatives reduce**
- 4. Building failure**
- 5. Regional flood protection is reduced.**

Once again, the timing is uncertain and effective action requires that the triggers are monitored.

<sup>34</sup> DEFRA. (2013). *The National Adaptation Programme Report: Analytical Annex - Economics of the National*. DEFRA.

<sup>35</sup> Deloitte. (2013). *Climate Adaptation Plan for Retail - Glanford Retail Park*. Swindon: Innovate UK.

## Business case and client profile



At the moment, adaptation is not seen as a selling point that would increase the price realised, particularly by property valuers (see Property Investment Valuation text box on page 45). On the other hand, a client with an enduring interest in the building (such as an owner-occupier) has a different fundamental purpose when procuring and is more able to take a long-term view and thus likely to see the business case for adaptation. The building's operating or whole life costs and its vulnerability to climate change become increasingly important factors here. A client representative at the expert panel stressed that whole-life costs must be put in the business case if there is a long-term interest:

“Otherwise, how can I put something in front of a senior person and explain to them what the key risks are?”

Several of the projects responded to this need. For example, the team for the Cliftonville project, a sensitive housing regeneration scheme by a local authority, said in their final report<sup>36</sup>.

“There is a need to minimise the financial risks for our clients in respect of refurbishment costs as the climate changes, and likewise there is a need to assess the short and long-term costs, benefits, maintenance and timing of retrofitting.”

“There is a need to minimise financial risks for clients as the climate changes.”

**Rule of thumb:** the case for adaptation becomes stronger the more enduring the client's stake in the building.

<sup>36</sup> Thanet District Council, Daedalus, Studio Engleback, WT Partnership, SDA Architects, Radius. (2013). *Cliftonville Design for Future Climate II 300245 Final Report*. Swindon: Innovate UK.

### Weak link between capital and operating costs

**Even when a client has an enduring interest in the building, making the case for higher capital costs in the expectation that these will be offset by lower operating costs is not always straightforward. A contributor to the expert panel explained:**

“If you make your building more expensive ahead of where the market is, it becomes very difficult to roll those costs into the way the projects are financed.”

Facilities management costs – maintenance, energy, and so on – have a fairly direct linkage to construction costs. However, operational costs associated with running a business and maintaining profitability do not and are less likely to be considered in a conventional cost benefit analysis. It is extremely unlikely for the budgets to be held by the same part of the organisation. For example, the people in day-to-day charge of operating businesses understand the cost impact of two days lost through flooding but may have no influence on where their business invests its capital. A contributor to the expert panel said:

“Very often revenue decisions are separate from capital decisions. You bring those together then you can have a discussion with the finance team and the operations people.”

To make a convincing business case is therefore down to bringing these three things together:

1. taking a life-cycle approach
2. getting a good idea of the cost impact of the risks
3. understanding how much capital needs to be invested

It is important that clients reach agreement with their designers on these issues at the briefing stage – otherwise failure to do so will add complications and costs further on in the design process.

The Environmental Sustainability Institute team concluded that:

“A strong client is required, and often with the requirement for capital and operational budgets to be held by the same person. For example, it would be harder to pursue an adaptation strategy in a speculative office block, or even where there is a single client organisation but where capital and maintenance budgets are held in separate departments<sup>37</sup>.”

The expert panel identified that it would be useful to have a simple verified ratio, or set of ratios for different building types, as a shorthand to make it easier to understand the relationship between capital expenditure and operational expenditure. As one contributor put it:

“We need a business dashboard and a set of tools to help promote decision-making around this. You can do profiling around certain building types and fill the clear gap between what the climate scientists are saying and how you make a decision on that.”

**Rule of thumb: the case for adaptation becomes stronger the more the client’s capital expenditure and operational expenditure decisions are connected.**

<sup>37</sup> University of Exeter, Leadbitter, Stride Treglown, Method, Halcrow Group, Cornwall Environmental Consultants, Ward Williams Associates. (2013). *Adaptation Study for the Environmental Sustainability Institute*, Cornwall. Swindon: Innovate UK.

## Business case and client profile

### Cost-benefit analysis

The chief method of demonstrating the value of investments and, indeed, of comparing one investment against another, is cost-benefit analysis.

Benefits and costs are expressed in monetary terms, and are adjusted for the time value of money, so that all flows of benefits and project costs over time are expressed at their net present value (see box below). Calculation of the net present value requires agreement on the payback term – i.e. how long the costs should take to be paid back, and a discount rate – i.e. the value today of benefits that will accrue in the future.

#### Visualising the time value of costs and benefits

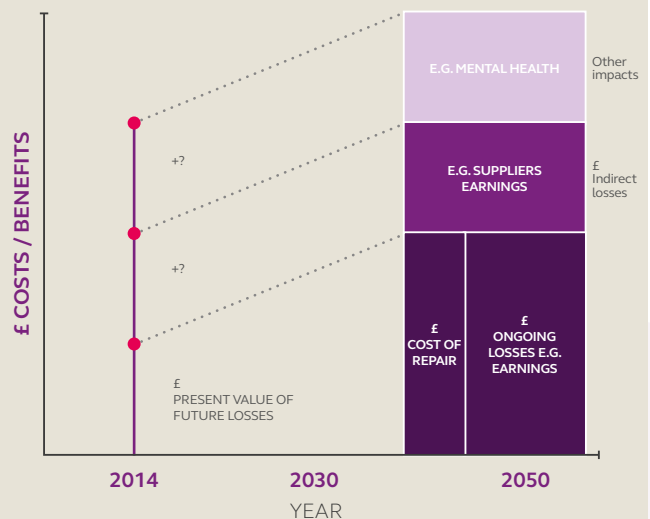
At a D4FC legacy conference, Peter Gist of Arup<sup>38</sup> visualised the time value of money and the effect of unquantifiable benefits very simply in the graph below. It imagines the future benefits and tracks them back to the present day – and their present value.

Arup lists the factors that impede investment as:

- high discount rate
- future losses a long time ahead
- uncertainty and imperfect information
  - climate change effects (sea levels, temperature, precipitation)
  - frequency, severity of weather events (and regional, local effects)
  - impacts on environment, people
  - effectiveness of resilience measures
- missing markets ('externalities')
  - impacts not measurable in financial terms

- misaligned markets
- investors will not capture benefits, governance issues
- 'public goods' (often related to large public infrastructure)
- budget constraints.

#### Invest if value of benefits exceeds cost



**B > C if PV of future losses > cost of investment in resilience**

<sup>38</sup> Gist, P. (2014, February 26). *Building a Resilient Future: an Economic Perspective*. London: Innovate UK.



### Payback periods

The 2013 *Is UK Plc climate-ready?* survey<sup>39</sup> by PwC UK found that 35% of respondents claimed that an acceptable payback period for a climate resilience investment could reach from seven to 10 years, while 15% would accept a payback period of 11-15 years, and over 10% would accept a return on investment that takes more than 16 years.

While these longer periods extend the likelihood of an extreme event occurring that would justify the investment, they are not long enough for incremental trends to be discernible against the natural variability of weather. In that sense, it is not the very long-term thinking required to safeguard the UK's built environment. Nonetheless, it indicates widespread awareness that longer-than-standard payback periods are needed for investments.

For example, the British Trimmings team found that:

“Whilst these (2050 and 2080 data) were academically interesting, the client found them to be rather too distant to affect decision-making with regard to their financial model. A further batch of 2030 datasets was therefore introduced at a later stage in the project and these were found to show significant changes within this relatively short time span and thus held more relevance to the client.”

(British Trimmings report)

### Discount rates

**Clearly, the discount rate dramatically affects the net present value calculation. The higher the discount rate, the lower the weight placed on future benefits and costs. Since the rate chosen is effectively a guess (albeit carefully considered), the net present value tends to be calculated using a range of rates to see how they affect the analysis.**

Private investors making decisions about whether to pursue a project traditionally apply discount rates that are based on their cost of capital, with a premium added to reflect the risk attached to the project. They choose investments by comparing ‘internal rates of return’ – the rate that makes the net present value zero. The higher the internal rate of return, the better the investment.

### Social discount rates

There are other approaches, described as ‘social’ discount rates. For example, local authorities might select a discount rate that society ‘should’ use to value the future, based on ethical considerations and value judgments. In some cases, this approach has been used to justify very low discount rates where (the very significant) benefits of current investment will only accrue in the distant future.

For example, the influential Stern Review (Stern 2006) argued for discount rates of around 1.4 % (in real terms), allowing it to conclude that the current generation should expend resources reducing greenhouse gas emissions, even if the majority of the benefits of mitigation would not arise for many decades (or even centuries).

Needless to say, a very low rate is unlikely to satisfy business clients whose fundamental purpose is to make money and whose primary responsibility is to themselves and their shareholders, and not the wider community. It is, however, worth reflecting on the dependence that such businesses have on the wider community and the self-interest they therefore have in helping to protect it – see text box on the next page.

**Rule of thumb:** the business case for adaptation becomes stronger if costs and benefits over time can be taken into account in establishing initial capital expenditure.



D4FC: British Trimmings

<sup>39</sup> Pricewaterhousecoopers. (2013). *Is UK Plc climate-ready?* Business Green.

## Business case and client profile

### Responsibility, the common good and regulation

There is an ethical dimension to adaptation which is very similar to that underpinning the climate change mitigation effort. As the Secretary General of the United Nations Ban Ki Moon stated in relation to government and business action:

**“Adaptation is both a practical need and a moral imperative.”**

Because climate change is indiscriminate and has wide societal consequences, there is a moral responsibility on private individuals or organisations to prepare for it. Summed up as enlightened self-interest, this recognises that we all depend on each other for business success, continued public services and, ultimately, survival.

The fundamental purposes of buildings, as seen by clients at least, rarely extend to supporting the common good, although they might do so by default or coincidentally<sup>40</sup>. Nonetheless, clients ought to adapt their buildings for the common good. This would include doing things that reap communal benefits but are only a cost to the individual client – such as incorporating and maintaining sustainable urban

drainage systems<sup>41</sup>. The question of responsibility, and in particular who should pay, is an important point.

Several factors that influence a building client’s vulnerability to climate change – the building’s location, or far-flung countries if it relies on international supply lines, for example – occupy this ill-defined territory between private interest and common good. However, because clients in these instances do not own these other areas or the assets affected, they are less likely to regard the burden of responsibility for dealing with them as theirs – creating what is known as a ‘moral hazard’. Instead, they rely on publicly funded safeguards or the coincidental actions of other private interests, which might or might not be sufficient.

There may be times, however, when publicly funded safeguards are ineffective or cannot reasonably be imposed, in which case private action might need to be compelled through legislation. The D4FC projects encountered this dilemma frequently, with many of the final reports calling for the gap between private interest and common good to be closed by regulation – see Section 5.

**“Adaptation is both a practical need and a moral imperative.”**

<sup>40</sup> The common good is protected by the planning system in the UK.

<sup>41</sup> New legislation, the Flood and Water Management Act 2010, will require housebuilders to meet stringent new standards for managing water run-off using sustainable drainage systems like ponds and reed beds. The key objectives are to manage the flow rate and volume of surface run-off to reduce the risk of flooding and water pollution for the common good.

### Avoiding stranded assets

**An investment can also be thought of as a kind of insurance – paying a fair amount now to avoid paying much more later, known as ‘expected averted losses’.**

The costs are ‘sunk’, i.e. irretrievable, and are used to build things like flood defences. They only become effective when they fulfil their function, which makes them a less attractive option because of the chance that they will never be used in the lifetime of the building owner. To build without investing in them, however, is to risk creating what are known as ‘stranded assets’ – assets that over time become unadaptable and inoperable because of, among other triggers, climate change<sup>42</sup>. The risk of stranding is the key driver for sinking costs, and has the potential to have significant consequences for the national economy if enough assets are affected.

“Averted losses – pay a fair amount now to avoid paying much more later.”

### Other measures of value

**Depending on the client’s fundamental purpose, there are other, less easily quantified measures of value that have no financial dimension but which are nonetheless persuasive. Accounting for these is known as ‘triple bottom line’, or social or environmental return on investment analysis.**

This bases the assessment of value in part on the perception and experience of stakeholders, finds indicators of what has changed and, where possible, uses monetary values for these indicators (see text box below). For schools, hospitals and care homes, for example, the benefits of adaptation can be measured in terms of improved educational outcomes, better rates of recovery and better quality of life. A contributor to the expert panel described some work for a local authority:

“There was a proposal to put office space in the basement. Following our study they decided not to because of the potential of flood risk in the area. It wasn’t a financial decision, it was purely based on potential risk to future users of that building.”

On the other hand, a representative of a long-lease tenant client said that they tried to monetize all losses and value to quantify the potential risk, warning however that ‘it does tend to fall on deaf ears’.

### Example: monetising an adaptation benefit

The Environmental Sustainability Institute team undertook extensive computational modelling work to explore the thermal comfort of occupants under various future climate scenarios, discovering that overheating was inevitable. To give their innovative results some visibility in the cost-benefit analysis, they attempted to monetise the benefit of improving thermal comfort.

“We did this by relating the potential drop in productivity with increasing departure from comfortable conditions. Because we had calculated the predicted mean vote (PMV – a subjective measure

of thermal comfort) in each room of the building over a year, we could adjust the economic output from the building by the changes in relative productivity, where we took the productivity of the building as being £34,520/FTE, which is the mean economic output within the education sector in Cornwall. From this, we observed that for a totally unadapted building in 2080 and a light clothing policy, the loss in productivity could be as low as £65,000 and as high as £303,000 over the summer based on the 2080 low and high scenarios respectively. In other words, the difference could be worth millions of pounds over the building’s life.”

<sup>42</sup> The threat of stranded assets is a serious economic concern. The University of Oxford’s Smith School of Enterprise and the Environment warns that these risks ‘are poorly understood and regularly mispriced, which has resulted in a significant over-exposure to environmentally unsustainable assets throughout our financial and economic systems. Current and emerging risks related to the environment represent a major discontinuity, able to profoundly alter asset values across a wide range of sectors.’ [www.smithschool.ox.ac.uk/research/stranded-assets](http://www.smithschool.ox.ac.uk/research/stranded-assets)



### Lack of regulation or agreed standards

**Clients need building designers to demonstrate that risks from climate change matter, and that the measures to address them are reasonable and a good investment.**

This is a challenge, especially in the absence of regulatory support, formalised competence, or established standards – the bedrocks of mainstream professional design practice (see Section 5).

Of course, this challenge is a feature of innovation generally – suppliers upskilling in advance of mainstream practice to meet a need that customers do not yet know they have.

The current lack of regulations and standards has an enervating effect on the business case. This was a recurring theme in the expert panel meetings and in the D4FC project reports. The most obvious effect is that clients have almost no compulsion to adapt, making it relatively easy to say no to building designers. Beyond that, the absence gives the false impression that adaptation is not important. If it were, then it would be regulated.

**Rule of thumb:** clients' willingness to accept the business case for adaptation becomes stronger the more robust the rationale is and the more convincingly it is communicated.

“Lack of regulation and standards has enervating effect on business case.”



### Financial stakeholders

**The head client, ie the body that contracts with the lead building design consultant on a project, is sometimes only a part-stakeholder in the finished building.**

There are always other important stakeholders, such as users and members of the local community. However, perhaps more important to the business case are the financial stakeholders – investors, insurers, and joint venture partners – all of whom hold some sway over investment decisions.

These stakeholders are concerned with different timeframes. In the case of the Glanford Park project, the contractor was concerned with the build and first year of occupation. M&S, the anchor tenant, had a lease of 25 years, while the institutional investor had an interest in the development's 60-year life span. Knowing these different durations of interest gives building designers an enhanced brief that allows them to make more compelling arguments in favour of adopting measures.

“Climate change will affect valuations only after it affects yields or rental incomes.”

#### Property investment valuation

The Betws Washery project team realised that inherent conservatism of property investment valuation practice restricts developers from adopting climate change adaptation measures.

The market dictates that the value of real estate comes from the rent it can generate or its yield, which in turn constrains developers' budget costs and profits. Therefore, for adaptation measures to be affordable by the developer they must either improve the yield or increase the rent, or both. Valuation of yield for commercial projects tends to be based on historical data such as local comparables, and resources such as the Investment Property Databank<sup>43</sup>.

In speculative projects, the investors are the main driver for the project's specification, and the development budget is set with them in mind. Developers attempt to get the best deal on the basis that they know how to provide what investors want. The specification will adopt institutional norms, influenced by property investment valuers.

Sometimes the project hinges around a deal with an anchor tenant (a foodstore, in the case of this project),

and so the tenant's specific requirements to improve operational efficiency/cost become a significant driver. Even so, developers are limited in the extent to which they can meet tenants' requirements. This is because either the yield has to improve as a result of the measures – less likely when it is an operational value consideration – or the tenant has to pay higher rent. Generally speaking, higher rents must be outweighed by operational savings for this to work, dampening tenants' overall influence.

When the investor is the driver (and location and rent are fixed), adaptation measures can be incorporated if they improve yield. However, because property valuers (who determine the yield) rely on historical data and quantitative evidence, they rarely recognise the benefits of implementing measures to adapt to future climate change. Until they do, it is very difficult for anyone at the valuation stage to gamble with yield. A 2009 RICS paper<sup>44</sup> acknowledges that the role of the valuer is merely to reflect the behaviour of markets and, by inference, not to create markets. This suggests that climate change will only influence property investment valuations reactively, only after it has been proven to affect yields or rental incomes.

<sup>43</sup> See [www.ipd.com](http://www.ipd.com)

<sup>44</sup> RICS. (2009). *Sustainability and commercial property valuation*. London: RICS.

## Business case and client profile



**D4FC:** Co-op head office

### Insurer power

**The insurance industry has an important role in influencing climate change adaptation since it pays out to policyholders whose properties are affected by extreme weather events.**

In effect, it underwrites much of the UK's decisions to invest in buildings, and by manipulating premiums further in response to modelled future increases in risk by, for example, either rewarding policyholders who adapt or penalising those who do not, it can incentivise adaptations<sup>45</sup>.

Quoted in a report by the Carbon Disclosure Project, *Insights into Climate Change Adaptation by UK Companies*<sup>46</sup>, the OECD said:

“Properly set insurance premiums can, in principle, send appropriate signals to policy holders to undertake adaptation measures to reduce exposure to various risks, including those posed by climate change.”

These trends are clearly important for businesses, for whom insurance is a significant cost, and should also influence investors. For building designers interested in promoting the case for climate change adaptation, framing their pitches and recommendations in the context of these insurance trends will reinforce their case.

<sup>45</sup> Niehorster, F. (2013). *Warming of the Oceans and Implications for the (Re)insurance Industry*. Geneva: Geneva Association.

<sup>46</sup> Carbon Disclosure Project. (2012). *Insights into Climate Change Adaptation by UK Companies*. London: DEFRA.

### Investor power

**Investors have been wielding their power for several years in the area called environmental, social and corporate governance by influencing how asset managers invest portfolios.**

Those with an eye on the long term – pension funds, holders of insurance reserves, and so on – are most interested. They screen investments for their approach to climate change mitigation (for example, under the Carbon Disclosure Project<sup>47</sup>) and, increasingly, adaptation, demonstrating the financial value of concerns about future climate. Investors have been clubbing together to exert their influence. The Global Investor Coalition on Climate Change<sup>48</sup> (GIC) recently carried out a survey, the 2013 Global Investor Survey on Climate Change<sup>49</sup>, that showed that:

“A majority of investors view climate change as a material risk and as a consequence have retained, and in many cases advanced, their commitment to addressing climate change in their investment activities. This is despite wider economic challenges and continuing policy uncertainty.”

An earlier GIC report, *Climate Risk and Financial Institutions: Challenges and Opportunities* (2010)<sup>50</sup> set financial institutions the responsibility to act in the face of climate change.

“Investors are likely to look favourably on organisations that take climate resilience seriously.”

“If changing conditions are not actively managed, investments and institutions may underperform. Institutions managing investments in long-lived assets have both a direct financial risk to consider and the opportunity to create value by working proactively with their clients and other stakeholders to take steps to manage the risks.”

Several institutions have already acted. The International Finance Corporation’s<sup>51</sup> Climate Risk Pilot Program, for example, has produced initial case studies<sup>52</sup> that assess approaches to real-sector climate risk and adaptation, in addition to the present analysis of risks to financial institutions.

This is feeding through to companies. Asked to rate the most compelling reasons for developing a climate resilience strategy in the PwC survey, the top-rated reason was that ‘high levels of climate resilience [are] likely to impress investors’. While not yet mainstream, investors are likely to look favourably on those organisations that take climate resilience seriously because:

“It becomes a fundamental question about whether or not you will get a return on your money.”

<sup>47</sup> See <https://www.cdp.net/en-US/Pages/HomePage.aspx>

<sup>48</sup> See <http://globalinvestorcoalition.org/>

<sup>49</sup> Mercer. (2013). *Global Investor Survey on Climate Change 3rd Annual report on actions and progress*. Global Investor Coalition on Climate Change.

<sup>50</sup> Vladimir Stenek, J. C. (2010). *Climate Risk and Financial Institutions: Challenges and Opportunities*. Washington DC: International Finance Corporation.

<sup>51</sup> Affiliated to the World Bank, the IFC’s purpose is to further economic development by encouraging the growth of productive private enterprise, especially in developing countries. Its *Performance Standard 1: Assessment and Management of Environmental and Social Risks and Impacts* says: ‘The client will establish and maintain a process for identifying the environmental and social risks and impacts of the project’ ... including ... ‘relevant risks associated with a changing climate and the adaptation opportunities’.

<sup>52</sup> Case studies and related reports are published on their website: [www.ifc.org/wps/wcm/connect/Topics\\_Ext\\_Content/IFC\\_External\\_Corporate\\_Site/CB\\_Home/Climate+Risks\\_Adaptation/](http://www.ifc.org/wps/wcm/connect/Topics_Ext_Content/IFC_External_Corporate_Site/CB_Home/Climate+Risks_Adaptation/)

## Business case and client profile

### Conference opinions: should investors apply pressure?

At the D4FC legacy conference, 53 respondents rated how strongly they agreed or disagreed with the following statement.

**Institutional investors such as pension funds and insurance companies should specify the extent to which future climate change must be allowed for in the design of properties they invest in.**

Most agreed, with one designer saying that it was ‘fundamentally important’ if clients are to take climate change seriously. A local government employee said that this should be integrated into their existing fiduciary duty. Among those who disagreed, one respondent felt that this was a ‘band-aid’ approach, with another in agreement, wanting regulation instead.

#### Results

	Disagree		Neutral		Agree	
Totals	3	0	4	7	13	26
n = 53	3		11		39	

### Other financial stakeholders

**There are other financial stakeholders to building projects – owners, tenants, and even the contractor – who have an influence over the extent of adaptation because the climate change risks are shared by or passed onto them.**

The team for the Admiral headquarters D4FC project acknowledged this:

“As Admiral commissioned the building of the office under the agreement that they will sign a 25-year tenancy agreement, they have had an active say in its design in order to ensure it meets their business requirements. As such, they have been influential in the development process and have a vested interest in ensuring low operational costs and in making long-term plans for its adaptation.” (New Admiral Insurance headquarters report).

**Rule of thumb: the business case for adaptation becomes stronger if all the project’s financial stakeholders can be shown to favour it.**

This multiple stakeholder interest was actively leveraged by the Glanford Park team, who found that accounting for all stakeholders’ interests revealed a better business case:

“By addressing climate risks early and holistically over the investment lifecycle from the multi-stakeholder perspective, adaptation options can also be shared, reducing the burden on any specific individual stakeholder and providing greater beneficial impact. A combined development-focused report which addresses multiple stakeholders’ risks and actions, would support this, and also illustrate transparency around decision-making.”

### Conference opinions: should clients advertise climate change readiness?

At a D4FC legacy conference (see Appendix 8), 53 respondents rated how strongly they agreed or disagreed with the following statement:

**Construction clients have a duty of care to inform purchasers/occupants of their buildings about the extent to which climate change has been taken into account in their design and construction.**

Most agreed. However, a respondent warned that even with this kind of action, recognition of the issue in the market is still not strong enough:

“I don’t think there is a big enough demand or regulation to enforce. Where is the awareness of energy performance certificates? How can we expect awareness of climate change adaptation?”

A neutral respondent agreed, saying that getting the purchaser and occupants to ask the question of the developer/building owner was the chief challenge. Another neutral respondent, a designer, felt that there was a benefit to construction clients in advertising their product as future-proof, but that this ought not to be enforced.

#### Results

	Disagree		Neutral		Agree	
Totals	1	1	5	7	14	25
n = 53	2		12		39	



## Other factors affecting the business case for adaptation

### Uncertainty

**Uncertainty ‘balloons at each step of the analysis’<sup>53</sup>, from the climate change projections all the way down to calculating the benefits of different adaptation options, making it difficult to interpret confidently.**

The contributors to the expert panels informing this report were very aware of this difficulty. An architect bemoaned the vast sum of variables:

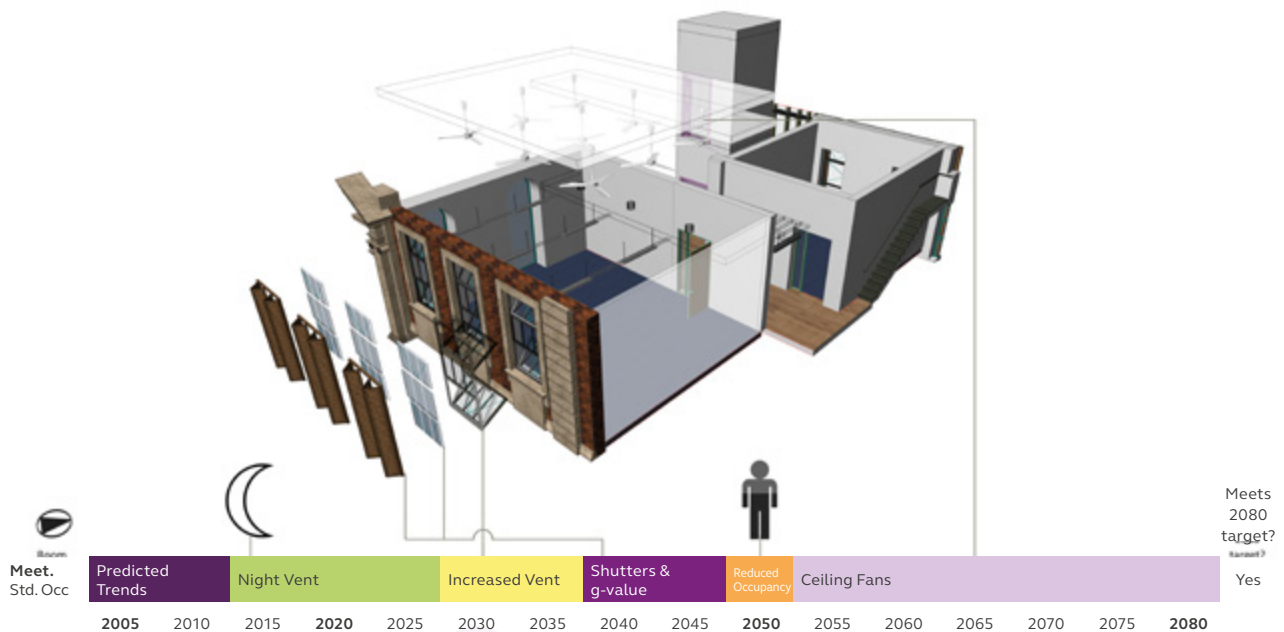
“Doing this exercise made us question very severely whether modelling is the right way forward because there are so many variables and each one could be a little bit wrong so that by the time you put them all together you are widely out of true.”

A specialist consultant said that the available information ‘doesn’t have the granularity to drive an investment decision at the level of a site’, stressing:

“Clients need to feel confident when they go to the board to ask for upfront investment that they have some basis to do so.”

Fortunately, there are decision-making methods that can handle deep uncertainty (such as ProCliP<sup>54</sup>) that assist clients to ‘adopt strategies which keep options open, reduce potential regrets and account for new information over time’<sup>55</sup>. ProCliP charts present a simple picture of the range that might be considered for any particular variable and thus potentially simplify the issue to that of time only (see ProCliP text box on page 84). There are other methods for clients considering their business cases<sup>56</sup>.

**Rule of thumb: the business case for adaptation becomes stronger when the decision-making tools can make sense of underlying uncertainty.**



**Figure 1:** Management B4 Fabric – exploded image of a room showing staged approach to addressing overheating (Bauman Lyons Architecture & Urbanism LLP)

<sup>53</sup> Nicola Ranger, A. M. (2010). *Policy brief: Adaptation in the UK: a decision-making process*. The Grantham Research Institute on Climate Change and the Environment and The Centre for Climate Change Economics and Policy.

<sup>54</sup> Probabilistic Climate Profile (ProCliP) is a tool (developed by CIBSE and UKCIP) that helps clients and design teams to agree parameters on which to base their climate-change strategies and to select appropriate weather files for building analysis. It is available as a free download from [www.cibse.org/knowledge/cibse-other-publications/cibse-probabilistic-climate-profiles](http://www.cibse.org/knowledge/cibse-other-publications/cibse-probabilistic-climate-profiles). See also page 84

<sup>55</sup> Nicola Ranger, A. M. (2010). *Policy brief: Adaptation in the UK: a decision-making process*. The Grantham Research Institute on Climate Change and the Environment and The Centre for Climate Change Economics and Policy.

<sup>56</sup> These techniques are set out set out in Appendix 2 of the Analytical Annex to the National Adaptation Programme, derived from DEFRA’s Economics of Climate Resilience (ECR) project, concluded in 2013. Its reports can be found here: <http://randd.defra.gov.uk/Default.aspx?Module=More&Location=None&ProjectID=18016>

## Business case and client profile

### Lack of evidence of effectiveness

**Building designers' current inability to back up their rationales for adaptation with some measure of proof that design strategies will work – however difficult this is when climate change is a moving target – makes it harder to persuade clients to take the plunge.**

To be able to do so would give clients more confidence in the effectiveness of adaptation generally and in the case studies' designers' skills in particular. Expert panel members felt that a programme of such case studies where the monitored performance data (albeit under current conditions) were open, transparent and free for all to exploit would be a considerable boost to creating a market for adaptation.

In reality, absolute proof will only come with the passage of time, making it very difficult to meet this ambition. Also, from the D4FC projects it is not clear that quantitatively assessed measures were more likely to be implemented than qualitatively assessed ones

**Rule of thumb: clients will see the business case for adaptation is stronger the more robust evidence there is that it carries on working over time.**

“There is a ‘lightning won’t strike twice’ inertia in the market.”

### Inertia

**The fact that different hazards carry different risks makes it likely that clients will respond at different rates.**

An architect member of the expert panel said:

“People do now think quite seriously about whether their building is going to get flooded. But for overheating you need a few hot summers to make you realise what’s going on.”

The corollary to this is that if clients accept the relevance of one risk, it might make them more receptive to accepting others.

However, the SNACC<sup>57</sup> research project discovered that it was only after the third time of flooding that people took action to reduce their risk, indicating a ‘lightning won’t strike twice’ inertia in the market. And if this is true for flooding, what will it take for clients to respond to overheating, where the consequences are relatively short-lived and less damaging? As another expert panel member put it:

“Even if we do believe there’s going to be a trigger event or aggregation of things ramping up to change, you still need to ask, ‘In whose working lifetime?’”

However, it remains likely that specific previous negative experiences of climate impacts – losses through flooding, overheating affecting productivity, and so on – will predispose clients to avoid them in the future.

**Rule of thumb: the business case for adaptation becomes stronger the more frequently and seriously the client has experienced the consequences of extreme weather events.**

<sup>57</sup> Suburban neighbourhood adaptation for a changing climate – SNACC – was a research programme funded by EPSRC, under the Living with Environmental Change Programme (LWEC) and was part of the Adaptation and Resilience to a Changing Climate (ARCC) Coordination Network. It aimed to investigate how existing suburban neighbourhoods can best be adapted to reduce further impacts of climate change and withstand ongoing changes. <http://www.snacc-research.org/>

### Vulnerability and setting priorities

**Of course, different vulnerabilities mean different responses to the same hazard. The fact that the south side of a building will overheat in summer may be of little consequence to the client whose most temperature-sensitive operations happen elsewhere in the building.**

A local authority client representative on the expert panel with oversight of school design pointed out that overheating has a detrimental effect on the performance of school children. He described this as having different priorities:

“The awareness of overheating depends on your priorities – it’s been a regular complaint in schools.”

In other words, whereas overheating is very important to a school, it is less important to some other buildings, making the client less likely to do anything about it.

“Different vulnerabilities mean different responses to the same hazard.”

**Rule of thumb:** the business case for adaptation becomes stronger the more vulnerable and likely to be affected the client’s priorities are.



D4FC: Edge Lane

### Conservative attitude to change

**Some clients will naturally shy away from change. In the context of a capital project costing millions of pounds, change adds risk, means more work, and can mean handing over control, all unwelcome.**

Four reasons clients might avoid change are:

1. the threat of extra capital cost: even if the adaptation in fact does not cost more, the threat that it might is still a strong disincentive
2. the threat that the adaptation creates unforeseen problems. There are many examples on the D4FC programme of this fear. The Cooperative headquarters is described as adopting a principle of ‘pragmatic innovation’ – nothing should be untested or cutting-edge in the pursuit of a sustainable design. Even the owner-occupiers or owner-managers involved in D4FC projects turned down adaptations on grounds of health and safety worries or maintenance liability concerns (Buro Happold, 2012). For example, the Edge Lane project reported that the proposal to use a certain kind of rainwater harvesting system to all WCs was ‘deemed impossible due to the risks of patients ingesting foul water’
3. the threat of extra work: the extra work for clients in understanding climate change adaptation and appraising design options might be unwelcome when they are already stretched in keeping on top of the rest of the design
4. the threat of losing control over the design team: clients can feel vulnerable if designers are making decisions or offering options on the basis of expertise which they do not share or understand, making them more conservative.

**Rule of thumb:** the business case for adaptation becomes stronger the more amenable the client is to innovation and the better the design team is at allaying clients’ real or misplaced fears.

## Business case and client profile

### Client size and operational complexity

**Clients who are large, complex businesses with many different departments and decision-making centres can find it difficult to respond to climate change, however logically beneficial adaptation might be for them.**

Since adaptation cuts across many traditional departments – health and safety, business continuity, business planning, risk assessment, and so on – knowing who to engage in the issue within client organisations may not be straightforward.

Talking about whether clients prioritise climate change threats and carry out risk assessments, one of the expert panel members said of the NHS:

“It’s undoubtedly true that it’s been done somewhere but finding the person is difficult.”

Another client representative agreed that it is a big issue:

“Where does it sit in the business? Who should be taking responsibility? It sits with me but it should sit with business continuity – they should be key stakeholders in a lot of these decisions. But they wouldn’t drive it, because it would add to their workload and they’ve got bigger priorities.”

In their report on the business case for climate change adaptation, *Climate Change Adaptation: Building the Business Case (2013)*<sup>58</sup>, the Institute of Environmental Management and Assessment identified precisely this issue:

“Within the ‘enabling’ phase, business cases are being made across a number of decision points within the organization and potentially by a number of internal personnel. A number of business processes with direct or related decision points exist, for example:

- internal approaches to risk management
- systems for business continuity
- environmental management systems
- other management systems (for example information management systems, quality)
- annual or other business planning
- procurement, specifications, tenders
- staff engagement programmes
- supply chain management
- capital expenditure

- company mergers, acquisitions, disposals (including reviews and due diligence)
- corporate strategy programmes (with sustainability or other vision statement)
- gated project management and finance controls (e.g. PRINCE 2).”

**Rule of thumb: the business case for adaptation becomes stronger the more the client’s business processes and decision-making are integrated, and able to respond to new factors, and involve fewer people.**

### Opportunity cost

**Whether assessed quantitatively or by gut feeling, clients might question the opportunity cost of adaptation. In other words, while they might understand the rationale for adaptation, they might also feel that doing so shuts down other, better options.**

The D4FC projects encountered this frequently, where recommended measures were discarded on the basis of unknown future technological advances.

For example, the St Faith’s School team adopted a wait-and-see overheating policy for some spaces based on reductions in internal heat gains from computers in the future:

“By 2050, technological improvements could ensure that the currently predicted overheating in the ICT suite does not materialise.”

Some D4FC teams agreed that expectations of future technological advances were sensible, especially where maintenance cycles presented opportunities to upgrade anyway. The team for the Environmental Sustainability Institute said:

“Although projected lighting efficacy and cost is not known, it would seem safe to assume that given the rapid recent advances in LED lighting, efficiency will significantly improve by the point of the first replacement of the lighting system, and subsequent replacements.”

**Rule of thumb: the business case for adaptation becomes stronger when the measures’ technology is tried and tested, and the cost-benefits are pronounced.**

<sup>58</sup> IEMA. (n.d.). *Climate Change Adaptation: Building the Business Case - Guidance for Environment and Sustainability Practitioners*. Institute of Environmental Management and Assessment.



### Learning curves

**Quite rightly, a client does not want to pay for the building designer's learning curve to gain the skills in offering adaptation services.**

They will be wary of excessive extra fees and suspicious that the state of professional knowledge and competence has yet to mature – discussed in Section 4. As an expert panel member and client representative said:

“When you come to clients you should know your stuff and clients aren't paying for learning.”

**Rule of thumb:** the business case for adaptation becomes stronger the more it is part of the building designer's normal service and well established in-house practice.

### Corporate social responsibility and reputation

**Although very much subservient to return on investment, many clients are strongly committed to behaving responsibly and communicating this to the world, especially where reputation matters.**

If a client can demonstrate their readiness for future climate change, especially if this has communal benefits, it can be a powerful incentive to adopt adaptations. For example, the head of environment at Saint Gobain, which tries to minimise the large quantities of water it uses in its processes, says:

“You have to look at the reputational risk you face if you end up as a big water user in a water-stressed area.”  
(quoted in PwC's *Is UK Plc climate-ready?* report)

And again, commenting on the Glanford Park project where the anchor tenant was M&S, an expert panel member confirmed the importance of corporate social responsibility.

“They saw the stores as an extension of the corporate personality of M&S.”

**Rule of thumb:** the business case for adaptation becomes stronger the more impact adaptation has on the common good, especially if the adaptation is very visible.

“Some clients are strongly committed to behaving responsibly and communicating this.”

### Competitive edge and new opportunities

**Commercial clients depend on their appeal to customers in competition with rival operations, and are always looking for ways to differentiate themselves in their market.**

Depending on their operation, being able to show how ready they are for climate change might eventually be a distinct advantage. Although this is currently a weak driver in the experience of the D4FC project teams, the Analytical Annex to the National Adaptation Programme emphasises it:

“Businesses could compete on the level of their resilience to weather and climate; this would make them less likely to face disruption. Demand for their products would increase as a result.”

For example, the North West Cambridge Development project identified that maintaining good levels of thermal comfort were needed:

“To ensure that the accommodation remains attractive compared with other market accommodation, and rental incomes can be maintained.”

The PwC report described this effect as taking advantage of the opportunities of climate change, which they listed as:

- increased demand for existing products/service
- reduced operational costs
- new products/business services
- increased production capacity
- investment opportunities
- reduced capital costs
- premium price opportunities
- wider social benefits.

**Rule of thumb:** the business case for adaptation becomes stronger if adaptation gives the client genuine competitive advantages and allows them to exploit new opportunities.

## Business case and client profile



D4FC: University of Sheffield

“Work with clients so they are part of process and understand it.”

### Engagement

**Because of their fundamental purpose, some clients are more inclined to consider climate change and the need to adapt than others.**

For example, because the purpose of the Environmental Sustainability Institute is to facilitate teaching, research and commercial application of environmental and sustainability knowledge, it wanted its building to be ‘living proof’ of its credentials. The impact of this positive attitude was limited, however, and capital cost still ruled its decision-making. As the final report says:

“In spite of an enthusiastic client, it is difficult to implement measures now that result in a significant capital cost uplift, even if it can be shown that in the longer term the overall cost will be lower.”

The expert panel emphasised the importance of engaging clients:

“It’s trying to work with clients so that they are part of the process and they understand it. That’s about changing the culture of decision-makers. If you don’t do that, you’re not going to get a very good building.”

**Rule of thumb:** the business case for adaptation is boosted when the client’s fundamental purpose or core business objectives encourage it to engage with the issue.

## Client profiles

The factors described in the previous pages are summarised in a checklist in Table 1. It can be used to make a loose preliminary profile of your client to gauge their predisposition to adaptation.

BUSINESS CASE DRIVERS	Weak				Strong
<b>Clients' financial approaches</b>					
Costs and benefits over time can be taken into account in establishing initial capital expenditure.					
Adaptation gives the client competitive advantages and opens up new opportunities.					
Client's financial stakeholders favour adaptation					
Client's capital expenditure and operating expenditure decisions are well connected					
Client's business processes and decision-making are integrated, able to respond to new factors, and involve few people					
<b>Clients' level of engagement</b>					
Client's stake in the building endures beyond completion					
Client's fundamental purpose promotes adaptation					
Adaptation has a visible impact on the common good					
<b>Vulnerability of clients' buildings and operations</b>					
The building and/or the client's business is vulnerable to the effects of climate change					
Client has experienced the negative consequences of extreme weather events					
There is a certainty of future risk					
<b>Clients' decision-making</b>					
The rationale for adaptation is robust and convincingly communicated					
Client's decision-making processes can cope with underlying uncertainty					
<b>Client's attitude to design</b>					
Adaptation strategies and technology are trusted and its cost-benefits are pronounced					
Robust evidence that adaptation works					
Client is amenable to innovation					
Adaptation is part of building designer's normal service and well-established practice					

**Table 1:** Rough checklist derived from the rules of thumb and grouped loosely into general categories and order of importance. It will help tell whether a client is or should be interested in adaptation.

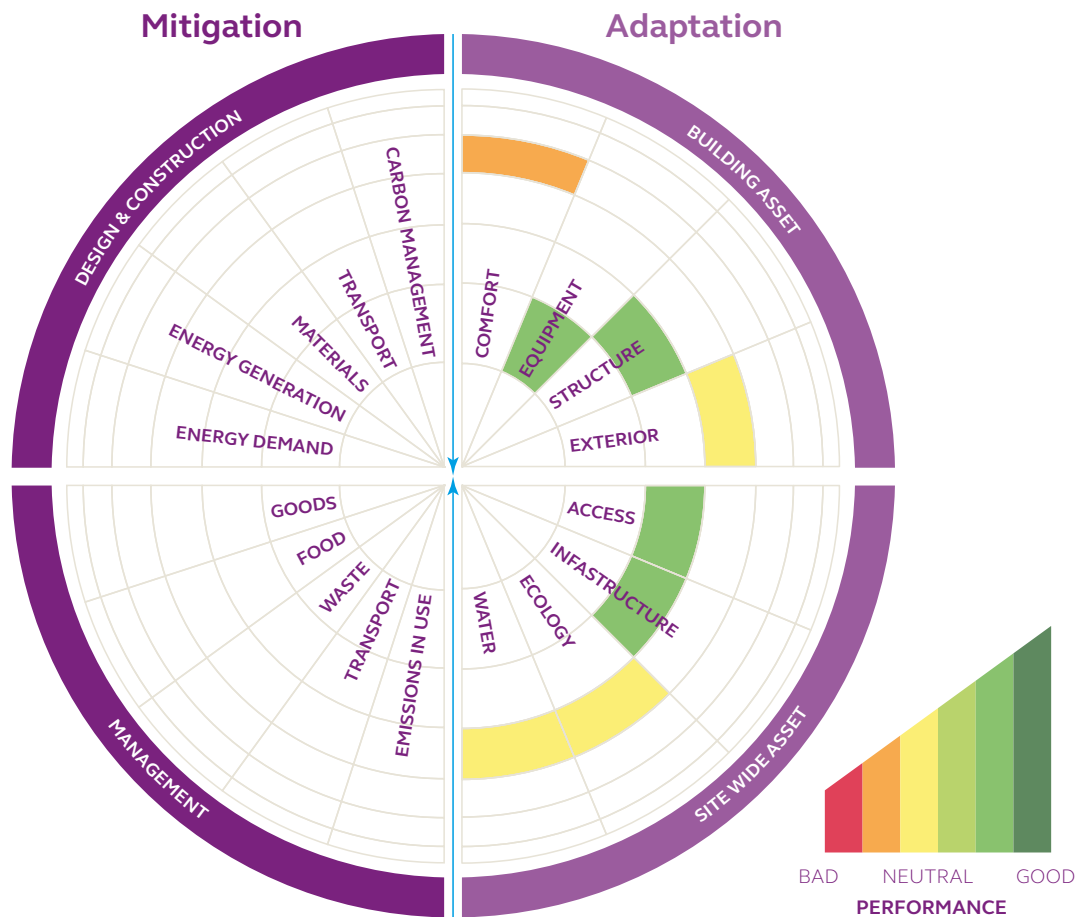
Provided there are opportunities to consult the client, this checklist can be a useful prompt to open up discussion that shifts the focus very starkly onto the business case. In this way, both client and building designers can quickly either rule out adaptation or agree to explore it further in the design. One architect member of the expert panel is already doing something similar:

“We do change the conversation depending on the client. For a commercial client we talk purely about money, about the saving. With local authorities we talk about having a strategy that delivers more for less. With some clients we don't even try – we don't like wasting time or coming bruised out of a conversation – there's no point. We know early on who it's worth talking to – we're always looking for the innovators.”

## Business case and client profile

Large consultancies may also have established ways to broach the subject. Sheffield Engineering Graduate School demonstrates Arup's method. They ask a series of questions under various headings which indicates where the client should concentrate its adaptation efforts.

### Arup Climate Change Adaptation Framework output diagram



Knowing who to talk to can be an issue. In multi-partner client bodies or with local authorities, there are often many decision-makers. In these situations, building designers must understand who they are talking to and adapt what they say accordingly.

#### Prevailing economic conditions

**A major concern that swamps any assessment of a client is the prevailing economic conditions.**

As already seen, this affects the conversation before the professional appointment. It also impacts heavily on what can be built through value engineering. Many clients in the D4FC projects, especially public sector ones, focused on the availability of capital and funding constraints or budget cuts. For example, as one of the last projects to

be procured under the Government's Building Schools for the Future (BSF) scheme, the Harris Academy was 'heavily affected by major cuts in capital funding'.

#### Current awareness in the client body

**Are today's client bodies – corporate, local authorities, commercial, private, and so on – sufficiently aware of their need to adapt to climate change?**

Since climate change has more and potentially far greater impacts beyond its effect on buildings, are client bodies capable and ready to act? After all, with the experience today of floods bankrupting businesses and the very likely future changes predicted by the IPCC, it would seem irresponsible not to be.



### Business awareness

**In Europe, some sectors such as the utilities have been planning for resilience for many years<sup>59</sup>.**

In the UK, the organisations responsible for essential services and infrastructure must report on risks to them from climate change and how they plan to respond under the Government's 'adaptation reporting power'<sup>60</sup>. Although large, these companies are however atypical. Their products and services are disproportionately affected by weather and have national strategic importance, which gives them special status.

**“UK essential services must report on risks to them from climate change.”**

For the vast majority of businesses, the realisation of business-critical dependencies has dawned but action is slow to follow. For example, a 2010 survey of 72 companies by Caring for Climate (UN Environment Programme) found that more than 80% agreed that climate change posed a risk to their products or services and that adapting could be a business opportunity. Unfortunately, two-thirds did not have a 'strong emphasis' on addressing the risks or exploiting the emerging opportunities.

Similarly, PwC's recent survey of 195 sustainability professionals found that over half regard the climate risks that their organisation will face over the next 30 years as 'moderate', requiring action to enhance resilience, or 'severe', requiring fundamental changes to the organisation. Yet the same survey found that 56% were 'unsatisfied with their organisation's level of climate resilience', indicating a lingering inertia in the face of the evidence.

In the UK, the Confederation of British Industry is encouraging businesses to take adaptation seriously. In its view:

**“Proportionate climate adaptation makes sound business sense and should build on existing corporate assessment and environmental management<sup>61</sup>.”**

### UK Climate Impacts Programme<sup>62</sup> awareness checklist

As part of its role to raise awareness of climate change impacts, UK Climate Impacts Programme publishes a helpful checklist to explore companies' motivation for taking adaptation action.

- Exposure to an extreme weather event, such as a flood or heatwave, brings into focus the impacts weather has on your organisation. This could raise questions about the potential for climate change to increase those impacts on, for example, reputation, health and safety, finances and operations.
- Having responsibility for infrastructure and business functions that are sensitive to changes in climate.
- A requirement from government or a client.
- A desire to identify positive opportunities and gain an 'early mover' advantage over competitors.
- Looking to adaptation as a follow-on step from mitigation.
- A desire to enhance your reputation and be seen as a market leader on climate adaptation.
- Maintaining business continuity is a matter of strategic importance.
- A need to make decisions on long-term assets (decades or longer) such as land-use, infrastructure or population groups.
- Having an individual with the skills, knowledge, motivation and leadership to engage their organisation with adaptation.

This list neatly sums up many of the pertinent issues that ought to be influencing businesses.

**“Proportionate climate adaptation makes sound business sense” – CBI.**

<sup>59</sup> Øystein Hov, U. C. (2013). *Extreme Weather Events in Europe: preparing for climate change adaptation*. Norwegian Meteorological Institute.

<sup>60</sup> This power is conferred to the UK Government under the Climate Change Act 2008, [www.legislation.gov.uk/ukpga/2008/27/contents](http://www.legislation.gov.uk/ukpga/2008/27/contents)

<sup>61</sup> Quoted in Carbon Disclosure Project. (2012). *Insights into Climate Change Adaptation by UK Companies*. London: DEFRA.

<sup>62</sup> The United Kingdom's Climate Impacts Programme – UKCIP - helps organisations, sectors and governments adapt to the changing climate through practice-based research, and by providing support and advice. [www.ukcip.org.uk](http://www.ukcip.org.uk)

## Business case and client profile

In our own straw poll of expert panel participants<sup>63</sup> – several of whom were building designers asked to put themselves in their clients’ shoes – all agreed that adapting buildings for climate change mattered to the British economy. However, agreement was only slightly less forthcoming when it came to considering their own needs. The reasons in favour were numerous, falling into four broad categories, see Figure 2.

<b>Concern for building performance</b>	Resilience in buildings
	Ensure running costs are reasonable
	‘Future-proof’ maintenance costs and cycles
	Previous impacts from weather
<b>Concern for business performance</b>	Business continuity
	Value of building stock
	Reduced insurance premiums
	Reduced risk
	Long-term interest in property
<b>Concern for the users</b>	Maintain a good environment in school
	Vulnerable user group
	Healthy, liveable, comfortable development
	Restricting fuel poverty
	Improved environment for staff and customers
<b>Concern for marketability, corporate social responsibility and reputation</b>	Attracting tenants
	Quality as a unique selling point
	Corporate social responsibility
	Pride in investment

**Figure 2:** Summary of results from Innovate UK expert panel straw poll of client reasons to invest in climate change adaptation.



**D4FC:** Great Ormond Street Hospital

Two-thirds of respondents said that they already make adaptation decisions and prioritise climate change threats. Of those that do not, one said that:

“Climate change threats are just one of a very long list of risks to be managed. Other risks will materialize more quickly.”

Another would ‘integrate’ climate change threats into the bigger risk management task.

Finally, two thirds of respondents had prepared or thought about preparing adaptation strategies, although their accompanying commentary was equivocal. One respondent said:

“Possibly at a business level, in terms of market research etc. Unlikely at building level – too far away.”

Another had a strategy for their best-performing stores but cast doubt on how it could be implemented. For another, the building type was important, saying that they had done a strategy for new build housing.

<sup>63</sup> See <https://connect.innovateuk.org/web/design-for-future-climate/documents>







# 3 Business opportunity and designer profiles

## Building designers' response

**Clients' limited uptake of recommended adaptation measures identified in the D4FC projects reflected the difficulty of making a compelling business case for them.**

Given that these were clients who had already committed to building projects with higher than normal environmental aspirations, it is clear that the market pull for adaptation services by mainstream clients is perceived by designers to be very weak. There is thus little incentive for building designers to press for change and to invest in developing expertise (see text box below). Some early adopter building designers are leading the way but at the moment they inhabit a niche that apparently appeals only to special kinds of client.

“Market pull for adaptation by mainstream clients is seen by designers as very weak.”

### Survey of building designers' attitudes to climate change adaptation

The Modern Built Environment Knowledge Transfer Network (MBE KTN) undertook a survey in 2013, *Climate Change Adaptation in the UK Built Environment*<sup>64</sup>, on behalf of the Environment Agency to gauge levels of knowledge, current attitudes, engagement and activity related to climate change adaptation among the UK's built environment community.

Among other things, it showed that climate change adaptation was generally a low or medium priority for their own organisations, and as part of their offering to clients, with many respondents highlighting the difficulty of making a convincing economic case for incorporating climate change adaptation in projects.

Respondents also expressed a desire for government policy to encourage and incentivise adaptation investment.

However, the expert panel members advising this report agreed that they have a duty to raise the issue and to engage with clients on adaptation even though their respective institutions are vague about the detail.

## Professional duty

**Contributors to expert panel meetings and at the Building a Resilient Future conference<sup>65</sup> were emphatically of the opinion that awareness of the potential impacts of climate change – as much as any other aspect of the design process that makes good resilient buildings – is a professional duty that is important for the long-term health of the nation's built environment.**

Given that there is now knowledge about the impact of climate change on buildings, professionals have a duty to:

- make themselves aware of the potential impacts of climate change on buildings
- equip themselves with the knowledge and skills to design buildings that acknowledge changes in the climate – either in-house or in collaboration with others
- inform clients of the potential impacts of climate change on buildings and to clarify the extent to which future climate is or is not to be taken into account in the design of a building.

“Building designers must, as a minimum, inform their clients of risks and record their response.”

<sup>64</sup> Modern Built Environment Knowledge Transfer Network. (2013). *Climate Change Adaptation in the UK Built Environment*. London: Environment Agency.

<sup>65</sup> See <https://connect.innovateuk.org/web/design-for-future-climate/documents>

<sup>66</sup> CIBSE. (2006). *CPD: A Guide for CIBSE Members*. CIBSE.

<sup>67</sup> CIBSE. (2014). *CIBSE Code of Conduct*. Retrieved from [cibse.org](http://cibse.org): [www.cibse.org](http://www.cibse.org)



## Business opportunity and designer profiles

The general duty is wrapped up in professional codes of conduct and continuing professional development curricula, but how it should apply to climate change impacts is, inevitably, non-specific. For example, Chartered Institution of Building Services Engineers (CIBSE) members must commit to the 'systematic maintenance, improvement and broadening' of their knowledge and skills. In its code of conduct, CIBSE requires that members shall:

*"Have due regard to environmental issues in carrying out their professional duties."*

It is equally non-specific about its continuing professional development curriculum, suggesting in its CPD: A Guide for CIBSE Members, under the broad umbrella of sustainability, carbon emissions and climate change as a 'possible' area for new learning and professional development.

*Guidance note 6 to the RIBA Code of Professional Conduct*<sup>68</sup> says:

*"Members are expected to continue to develop and update their skills, knowledge and expertise throughout their careers for the benefit of their clients and the quality of the built environment."*

Their continuing professional development curriculum again is broad, suggesting that architects 'might' consider:

*"Climactic [sic] design and the relationship between climate, built form, construction, lifestyle, energy consumption and human well-being."*

The *RIBA Plan of Work 2013*, the pan-industry model for project managing building projects, makes reference to the need to establish climate change criteria (and mentions climate change adaptation) but, as an outline framework document, of course does not specify what form these should take.

The expert panel concluded that professionals do have a duty to provide adaptation advice. As one panel member put it:

*"It's presumably our duty to inform the client that it's an issue and invite them to pay us to analyse it further. But you can't make them take your advice."*

However, the market for such services is currently extremely small and the level of professional experience generally limited. Given this constraint, the minimum position for the building designer is to inform their client about the risks and to record their response.

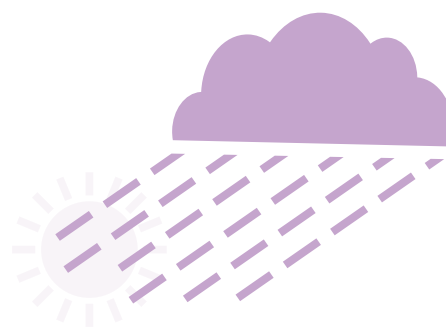
As another expert panel member said:

*"To inform is the first step. Whether or not you feel you need to persuade comes from your relationship with your client."*

Others, however, felt that adaptation should be rolled up into the standard service and not presented as an additional extra dependent on client sanction. After all, a building designer would not knowingly design a building that, on the balance of probability, will fail because of some other risk, such as fire. In the context of general agreement that climate change is a moving target and that assumptions have to be agreed upfront, another panel member said:

*"If the appointment is to design a building that lasts 40 years then it should last 40 years."*

The difference is, of course, that whereas fire risks are accommodated in regulation and established standards, climate change risks are not. Thus, the scope of the service is undefined, and the extent to which there is a responsibility to design a building to adapt to climate change is more uncertain. What is true is that designing for adaptation is as yet virtually entirely optional (see Appendix 2).



<sup>68</sup> RIBA. (2014). *RIBA Code of Professional Conduct, Guidance Note 6*. Retrieved from [architecture.com:www.architecture.com/Files/RIBAProfessionalServices/Practice/ProfessionalConduct/GN6CPD.pdf](http://architecture.com:www.architecture.com/Files/RIBAProfessionalServices/Practice/ProfessionalConduct/GN6CPD.pdf)

## Business opportunity and designer profiles

### The business opportunity for climate change adaptation

**Given the special first-principles thinking needed and the extra time involved, is there in fact an opportunity to exploit climate change adaptation competency for a premium fee?**

And does offering the service give a firm competitive advantages over its rivals? (Of course, mainstreaming adaptation through regulation and standards will automatically streamline the process to some extent – see Section 5.)

If there is a business opportunity presented by adaptation, it must complement clients' business cases for it. One cannot exist without the other, and any mismatch may result in wasted effort for building designers. They therefore must understand both the client's concerns and aspirations about adaptation and the vulnerability of what they intend to build. This report is an attempt to distil the key variables to make that task easier.

#### When offering adaptation services makes sense

Building designers have a professional duty to raise climate change risks and must therefore still decide how, and on what terms, to offer their adaptation service if the client wishes to explore adaptation.

There are many important factors involved here. Some are external, some strategic, others practical. All of them share a family resemblance – they are concerned with how clients approach their business cases. In deciding how to offer an adaptation service, building designers must be convinced that:

- it is aligned to their (the building designers') vision and mission statement
- their resources could not be spent more effectively in some other way
- the return from the time and resources invested is worthwhile, however that is calculated.

### SWOT analysis

**A SWOT analysis approach to building designers' suitability to offer adaptation services is a useful way to make sense of how they should offer it.**

Factors that are inherent to building designers, that they have some control over, are considered as either strengths or weaknesses. Those that are external to building designers, and which they have no control over, are opportunities or threats. The evidence used here is in large part based on the expert panels that informed this report.



**D4FC:** Bicester North West development

## Opportunities and threats

### Small market size

Although client attitudes are changing and the certainty of climate change impacts is improving, the market for adaptation is still small. Too many clients are unconvinced of its cost-effectiveness and think it too distant to be a present issue.

“There is a micro-market in adaptation and only a few designers serve it.”

### Is there a market?

Expert panel members were asked whether clients (of various kinds) would pay for specific climate change advice from building designers. Two thirds said they would, although the positives were all qualified:

“If specific challenges were identified then I might pay for some additional modelling.”

“Yes, if the advice was grounded in evidence and was cost-effective, value for money, proportionate and linked to other decisions/priorities/risks.”

Asked how building designers can pitch adaptation services and measures most effectively generated a whole range of answers that can be split into three broad categories.

**Engagement:** involve the client from the start; engage the client in decision-making; avoid jargon; be rational; demonstrate competence; be clear with recommendations.

**Strategy:** identify the risks; demonstrate experience and capability; assess risks for the pitch; use appropriate design tools.

**Recommendations:** accept the budget; be honest about limits; demonstrate financial and other benefits; measures should have multiple benefits; measures should have no or low cost; favour adaptive capacity through planned upgrading; aim for future resilience; make sure measures are costed; demonstrate payback periods or other forms of return on investment.

Crucially, members of the expert panels agreed that their experiences of understanding climate impacts and developing adaptation strategies for the D4FC projects meant that they think that they now design better buildings. Eventually, the discipline of adaptation will be just another way of improving the product, seamlessly integrated with everyday practice. Expert panel members said:

“It’s just about building better buildings. They have to be resilient and this is just another factor.”

“As a designer, it’s another tool to equip us to design better buildings. It’s an active, positive thing, and not an add-on and something you have to worry about. It’s actually just more information. The more info we have as designers the better buildings we’ll design. That’s how a good adaptation service should be presented to clients.”

## Business opportunity and designer profiles

### How big is the market?

The market for adaptation and resilience services is growing, but slowly and from a low base. According to the latest BIS information<sup>69</sup>, global 'adaptation and resilience (climate change)' sales were worth £68.7bn across all sectors. The forecast is for UK sales to continue to grow slowly but steadily, up to 6.1% by 2015/16 (relative to 2011/12).

“£22bn global sales.”

Global sales in the adaptation and resilience construction and retrofit sector were worth over £22bn (0.5% up on the previous year), while those in the adaptation and resilience architectural sector were worth nearly £9bn globally (up 5.5% on the previous year).

In the UK, £655m of these sales were in the construction and retrofit sector (down 2.1%), with £272m in the architectural sector (up 7.4%). To give an idea of scale, construction in general contributes about £90bn to the UK economy annually, which means that the adaptation and resilience contribution is relatively small.

This is a threat in that, given that demand is currently so weak, upskilling in adaptation and promoting it as a service looks like a poor bet for design firms. For instance, in one of the expert panels, a representative from a large multi-disciplinary firm described the size of the market as 'sufficiently close to zero as to not be measurable'. However, he did concede that there are opportunities but that the design community needs to create the market.

However, there is already a micro-market and currently very few designers serve it, meaning very little competition. With the right approach, skills and risk attitude, agile designers can be a big fish in a small pond. Better still, as adaptation becomes more mainstream, firms that are already expert may steal a march on their competitors.

A director of a small architecture practice and member of the expert panel has been trying to exploit an 'adapt and save' service in what they regard as the primary market, which is in existing buildings.

“A lot of 30s and 60s buildings, and a lot of Victorian warehouses are fundamentally sustainable and can easily be adapted to climate change.”

Another director of a small architecture practice agrees that there is a market.

“We see it as a business opportunity because we provide an adaptation service. We've got information sheets and case studies we can send out that explain why it's important.”

Doing this helps them to demonstrate their depth of expertise – to show that they are 'different from other people'.

<sup>69</sup> Department for Business Innovation and Skills. (2013). *Adaptation and Resilience (Climate Change) (A&RCC) Report for 2011/12*. London: Department for Business Innovation and Skills.



### Professional liability

**There is a possibility that failing to design buildings for future climate change will eventually be actionable under the law of professional negligence, perhaps even retrospectively (see text box).**

This threatens designers who fail to act on adaptation. But it may also threaten those whose adaptive designs, by virtue of their innovation, are untried and not based on any established standards or agreed best practice. A consultant architect on the expert panel wondered about the liability in the thoroughness of any service provided.

“You may become liable for all kinds of things. How far did you go? Was the process robust? Was it reasonable? This kind of thing is very difficult, particularly when the budget is tight.”

Many firms will be wary of this and might be advised to steer clear of it by their professional indemnity insurers.

However, until that moment arrives and the professional bodies agree and seek to achieve a common high level of competence, professional liability in adaptation work remains untested even as a latent concern. In any case, designers always have been asked to predict the future – although perhaps less explicitly. As an engineer for a large multi-disciplinary practice and expert panel member asks:

“Do we not do this all the time? For example, supposing a fire started here, would we all be able to get out in time? How likely is this type of explosion? How likely is it that a truck will drive into this point at this speed?”

Again, with prospective but more risk-averse competitors staying away, there is an opportunity for more adventurous firms to exploit.

**“Failure to design for climate change could one day be actionable under laws of professional negligence.”**

### Professional liability

Can a failure to respond to known trends in climate change make a building designer professionally liable? A 2013 report by the Chartered Insurance Institute, *Coping with climate change: risks and opportunities*<sup>70</sup>, concluded that it might. It envisaged a case where the building designer exposes a client to ‘an increased level of weather-related losses’ by designing poor-quality flood defences:

“Climate change may enter into such cases because it is now clear that historical weather conditions cannot be taken as the best guide to future experience.”

Two key factors will establish liability. First, is it possible to foresee the consequence? The report, the first version of which was published eight years ago, says:

“It is now generally recognised, including by the legal profession, that the date of knowledge, in respect of the concept of anthropogenic climate change, has passed.”

Second, could the person designing the flood defences reasonably have been expected to foresee the flood damage? Here the report is more equivocal.

“The test for standard of care is whether a competent body of professionals of equivalent experience to the professional in question would have taken climate change into account. It would also be necessary to consider whether a purchaser or employer would have paid a premium for any extra measures at the relevant time.”

Summing up this issue, another report – the Glanford Retail Park final report – concludes:

“Given the evidence, there is a real risk to developers and designers alike that if they do not show evidence that they have considered climate risks and have incorporated at the minimum ‘quick win’ or ‘low regret’ options then they are leaving themselves open to future liabilities from wider stakeholders.”

<sup>70</sup> Chartered Insurance Institute. (2013). *Coping with climate change : risks and opportunities*. CII.

## Business opportunity and designer profiles

### Design data

**The D4FC projects sometimes struggled to translate the UK Climate Projections 2009 (UKCP09) data into useable, trustworthy, easy to interpret future weather predictions that are easy to communicate to their clients.**

With much complexity and uncertainty in the basic data for this work, some firms are cautious about its accuracy and thus the effectiveness of their designs, with all the knock-on implications for reputation and liability.

However, the expert panels concluded that working with the data was better than not doing anything at all. A representative for a local authority client said:

“When you’re educating the client, you can talk about uncertainty. You can say that none of this is a certainty but from the data we have the risk is x or y. Then you’re giving them a choice about how you deal with x or y.”

Also, they were confident that over time not only would the data improve (through historical corroboration and refinements in modelling methods) but also that the design tools would improve too.

The D4FC projects also reported that the failure of regulations and standards to account for future climate change currently is a significant gap. This hindered the teams’ ability to ‘sell’ adaptation to clients, implies that the issue is not serious, and therefore exacerbates the current market failure. Since planning and regulations are

the bedrock of building design practice, the expert panel not only advocate updating them to promote the business case, they also want this done as soon as possible. (See Section 5)

“We could conceive of a regulation that would become standard practice in the 2019 Building Regulations.”

In a straw poll of expert panel members to see whether mandatory obligations to take climate change into account would be fair, nine out of ten said yes.

The opportunity here is to engage with and influence standard-setting by leading the discussion through practical experience, particularly that developed by the D4FC projects.

When adaptation practice mainstreams and new regulations come into force, those who have led it will inevitably have a commercial advantage over those cramming to catch up.

“Failure of regulations to account for climate change is a significant gap.”



### Strengths and weaknesses

#### Fundamental purpose

**All building designers have their own unique strengths, special interests, and particular characteristics that determine the kinds of projects they are suited to.**

This reflects their overarching design philosophy and experience, which, acknowledged or not, shapes the kinds of clients they attract and the emphasis they put on different issues.

As climate change adaptation shifts into the mainstream, particularly as regulations and standards change, designers will be forced to address it. In the context of offering adaptation services in 2014, however, the fundamental purpose of a building design firm needs to have the following qualities.

**Openness to innovation** – which means not only trying new things on live projects but also committed to voluntary research and development and continuing professional development. For example, an expert panel member and director of a small architecture practice is using building information modelling (BIM) extensively in their adaptation work and, very unusually, working with a quantity surveyor to add costs into the model as a way of addressing clients' business case concerns.

**Enthusiastic about the subject** – which means being knowledgeable enough about climate change science, clear-sighted about its impact on buildings, and good at communicating the issues. This was a recurring theme in the expert panels:

“It’s the way you engage even before they appoint you that may allow you to do some of this stuff.”

**Enjoy interdisciplinary openness and understanding** – which means designing from first principles, considering impacts holistically, and the enthusiasm and skills to work collaboratively with other members of the team.

**Aspiring to best practice** – the opposite of merely delivering regulatory compliance or only doing the minimum that reduced fees permit.

#### Size and organisational complexity

**The size and organisational complexity of a building design firm puts practical limits on what work can be contemplated.**

Firms with lots of staff, complex structures and high overheads compete in a different part of the market to those that are small, organisationally agile and have low overheads.

In the context of offering adaptation services, size and organisational complexity matter, affecting the effectiveness of resource allocation. The question is whether doing so is the best way to use a limited resource constrained by a fixed level of overhead. A senior engineer in a large multi-disciplinary firm on the expert panel highlighted this issue, especially in the context of declining fees and a depressed economy:

“If the reality is that we won’t get any more money, I’m not going to be able to persuade my business that we should be doing more work.”

## Business opportunity and designer profiles

### Skills and competence profile

**The D4FC projects revealed the extent to which developing adaptation strategies is interdisciplinary. In other words, success depends on a fusion of many traditional and less common skills, preferably in one unified team, with the competence to apply them in an integrated way.**

Climate change expertise, risk assessment, dynamic modelling, probabilistic interpretation, whole-life costing, options appraisal, cost-benefit analysis and, not least, effective team and stakeholder management, are all important parts of the adaptation skillset (see Section 4).

Needless to say, this range of skills is rarely seen together in a single building design firm, even large multi-disciplinary ones. Offering the service either involves existing staff learning new skills, employing new staff with the requisite skills, or collaborating with other consultants. All three have an impact on profitability and thus the business opportunity.

An architect for a small practice with a specific adaptation focus invests whole-heartedly in training.

*“We also invite the client to come along to the various courses as well as other consultants who we want to work with.”*

The same architect is also employing new staff from different disciplines. They’ve had an engineer with strong building physics credentials for many years, recently hired a landscape architect, and are searching for a quantity surveyor. Other architects have invested in dynamic simulation software to investigate design proposals at an early stage, taking a role that was traditionally the preserve of engineers.

By contrast, representatives from large multi-disciplinary practices report that they either invest in short e-learning modules – ‘nothing too in-depth’ – or, depending on the sector, not at all. An engineer for a large practice on the expert panel said:

*“I wouldn’t say there is a strong focus to train in this area because the market is still quite limited.”*

Interestingly, another representative of a large multi-disciplinary firm agreed, saying that until there was some normalisation, ‘I don’t know what I’d train people on’. On the other hand, the likelihood is that whereas smaller firms need to invest to acquire the skills, the larger ones probably already have good competence in their organisation and so do not have the need to invest so heavily.

### Market positioning and marketing

**Success in offering adaptation services seems to depend on how building designers position themselves. A strategic vision that encompasses adaptation, probably as part of a broader sustainability statement, has a dual effect.**

It legitimises early discussion with the client about adaptation and also attracts a certain kind of client. A housebuilder client on the expert panel talked about this as a useful marketing angle to ‘win the client over’ before the client makes a commission.

*“It would show that you have a depth of expertise that others don’t or aren’t interested in having.”*

Commenting on a small sustainable architect’s success in offering adaptation services, an engineer from a large multi-disciplinary firm conceded that reputation and market position are important:

*“The kinds of clients who come to you are expecting that kind of service anyway and so it’s relatively easy for you to introduce your additional service.”*

However, the expert panel thought that the sales pitch is not on adaptation but rather, for example, on optimising passive design so that the need for air conditioning is eliminated because that translates into an instant benefit. A housebuilder client said:

*“I don’t think adaptation is the selling point, unless you’re thinking about a bigger definition of adaptable and flexible buildings. Climate change adaptation by itself is not as appealing.”*



### Business model

**Building designers' business models – how professional services are sold to clients – need to account for sensitivities in the market about who pays for learning, value for money, and the building design's fitness for purpose.**

Discussing whether or not an adaptation should be a paid-for extra or rolled up as part of a normal service, a housebuilder client complained:

“Professionals have got to rethink their business models. As a client it's not fair that I'm paying for all this stuff that I think you should know anyway.”

However, as regulatory compliance is based on historic defined climate conditions, adaptation strategies must meet these as well as an agreed set (or sets) of projected future conditions. This is undoubtedly more work, and it is reasonable to charge more fees for it. It is also the case that, since every building project and its context is unique, virtually every building design job will require some allowance for research, regardless of whether the services include adaptation. Again, it seems reasonable that building designers' fees reflect this.

“Adaptation services demonstrate a depth of expertise that others don't have.”





## Business opportunity and designer profiles

### SWOT summary

**In summary, it seems that the state of the market at the moment can only offer fully commercial business opportunities to certain kinds of firms.**

While they undoubtedly have the expertise and resources to provide adaptation services, larger multi-disciplinary practices are restricted in how they can exploit the opportunities. (We can speculate that this is so for larger practices because their traditional markets are least likely to be interested in adaptation.)

On the other hand, some niche practices, especially if they have an innovative bent, a commitment to learning, and a deep interest in the topic, are already among the leaders in this field.

### Higher rates, extra fees or competitive advantage?

**When it comes to exploiting adaptation services in practice in advance of mainstreaming, there is no talk of being able to charge premium rates – i.e. fees at a higher hourly rate for the specialist service – in the current market. It does, however, appear possible to charge a ‘standard’ rate using one of two tactics.**

1. Roll up the adaptation design service in a standard service offer for a proportionately higher basic fee and defend the extra capital costs (if any) further down the line. Perhaps best suited to niche firms.
2. Inform potential clients about the risks of climate change and the benefits of adaptation, and offer an additional defined adaptation design service for extra fees. Depending on the extent to which doing so will jeopardise the chances of winning the job, building designers might also try to persuade clients to accept the offer. Again, they will have to defend extra capital costs (if any) further down the line in a cost-benefit analysis. Perhaps best suited to large firms whose fees are already comparatively high.

An alternative option is to subsume adaptation work into the standard offer without charging any extra time – i.e. offer it as a loss leader and reap the rewards of competitive advantage alone. However, there was no appetite among the expert panel members for doing this.

### The rolled-up service

**The first approach is confirmed by a niche architecture practice with a sustainability specialism. They are adamant that it is all part of their standard service:**

“We design Passivhaus and climate change adaptation stuff and haven’t put our fees up.”

The benefit for them is to demonstrate a greater depth of expertise in sustainable design compared to their competitors. They do, however, recognise that they may charge a higher standard rate than their competitors.

Another medium architecture practice agrees, although by extending their skills to include dynamic simulation to analyse the impact of future climate they have been able to secure fees that previously would have gone to the mechanical and electrical consultant. The benefit of this is in the efficiency of carrying out these services in-house and the opportunity to use modelling to inform early-stage design (and to be in full control of the inputs and outputs of the software).

Benefits other than fees extend to firms’ improved chances of winning work. For example, a small niche architect reports that their success rate on pre-qualification questionnaires and tenders has improved.

“We can speak very competently about what we might be able to do for the building, especially if it’s an existing building.”

They are very targeted:

“We go for projects that might want our kind of knowledge, and there is little competition in this area at the moment.”

“Fully commercial opportunities are only open to certain kinds of firms.”

### The bolt-on service

**The second approach is confirmed by a senior engineer for a large multi-disciplinary firm. Although they would usually not mention adaptation, if they did it would be:**

“An optional extra for sure because if we’d put it as part of the service, we’d lose out to our competitors.”

This fear reflects the construction sector’s recent experience of shrinking fees and tighter margins in the world economic recession. The Environmental Sustainability Institute final report supports the idea of extra fees, pointing to anecdotal evidence that:

“Professionals within design teams already feel the strain of needing to deliver increasingly more issues than previously e.g. BREEAM, soft landings, etc. within an unchanged fee.”

Meanwhile, the bruises from the recession are tellingly revealed by a senior engineer member of the expert panel:

“Our job is to build and sell and make money for shareholders. We deliver what we are instructed to do.”



## Business opportunity and designer profiles

### Streamlining practice

**The need for extra fees in part presumes that designing for adaptation takes longer. There is a lot of extra work involved, especially as the service necessarily means doing one set of calculations for current regulatory compliance and repeating it several times using different sets of data – after agreeing which data should be used.**

There is also extra management time. However, with experience, developments in multi-climate analytical techniques, and rethinking of practice, some expert panel members suggested that the service could be significantly streamlined.

Clearly, the D4FC projects were experimental, with designers developing both knowledge and strategies almost from scratch. Most of the innovation was concentrated in particular with developing, running and interpreting model simulations to explore overheating. However, the consensus in the expert panel meetings was that once this is in place, and with experience narrowing the range of options to be explored, adaptation work should not take too much extra time.

“Designers were developing knowledge and strategies almost from scratch.”

### Integration with mainstream design processes

**The Sheffield Engineering Graduate School was a rare example of a D4FC project being integrated with the main design process – both ran concurrently, with staff collocated, permitting a fluid exchange of ideas.**

According to independent unpublished research<sup>71</sup>, the project lead found it difficult to ascribe specific effects of the D4FC study on the project because of this, claiming that much of the analysis fed into the design process rather than producing specific ‘extra’ design work.

### Sharing the model

**An architect for a large architecture practice said that iterations between different organisations slows things down.**

“If you have to iterate different simulations back and forth it just takes too much time.”

Much better to share the model electronically (if the ownership and liability issues can be overcome), without restricting the amount of iteration unduly to make it easier to combine measures and interpret results.

<sup>71</sup> Rachael Grinnell, a PhD student at Loughborough University, has analysed many of the D4FC final reports and interviewed key players from the projects for her thesis. Her insights have also informed this report.

### Establishing standards and practice

**The team for the Environmental Sustainability Institute agreed, reporting that in the absence of established standards and practice, their work would not have been possible without Innovate UK funding.**

“It would have been very challenging to produce these results at this level of detail alongside the normal pressures and timeframes experienced at design stage. This is because the problems encountered are complex and often required bespoke approaches to defining success criteria for the adaptation measures. It is likely that the time taken to undertake future adaptation studies could be reduced if agreed performance standards and methodologies are defined (i.e. so that others do not need to ‘reinvent the wheel’).”

The need to standardise the offer to make it more client-friendly is clear-cut, as the St Faith’s School report makes clear:

“It is essential to integrate adaptation work into the standard design process now to deliver more climate change resilient buildings for the future at the most cost-effective stages in the procurement process.”

### Updating professional contracts

**Mainstreaming adaptation would also be helped by updating the standard terms and conditions for professional contracts, and making it a standard part of the project management review process. As a consultant on the expert panel suggested:**

“If it’s listed as an offer in the standard service schedule, it’s got visibility and people can tick it off as they like.”

Also, the adaptation process should be a formal part of the gateway review process in the same way that tabs are kept on, for example, regulatory compliance or health and safety.



# 4

## Business competencies for adaptation

### Building designer competencies

It is clear from the D4FC projects that the competencies needed to deliver adaptation services are mostly a matter of extending existing skills rather than developing new ones: defining objectives, agreeing targets, assessing risks, modelling, identifying options, appraising options, and justifying recommendations.

These are all skills and methodologies that are quite widely used in the industry. However, to support adaptation design, they need to be used in different ways, with a different emphasis, and in situations where their use is currently unusual. For example, the use of dynamic simulation models to consider overheating rather than regulatory energy compliance and for building types where overheating is not routinely considered.

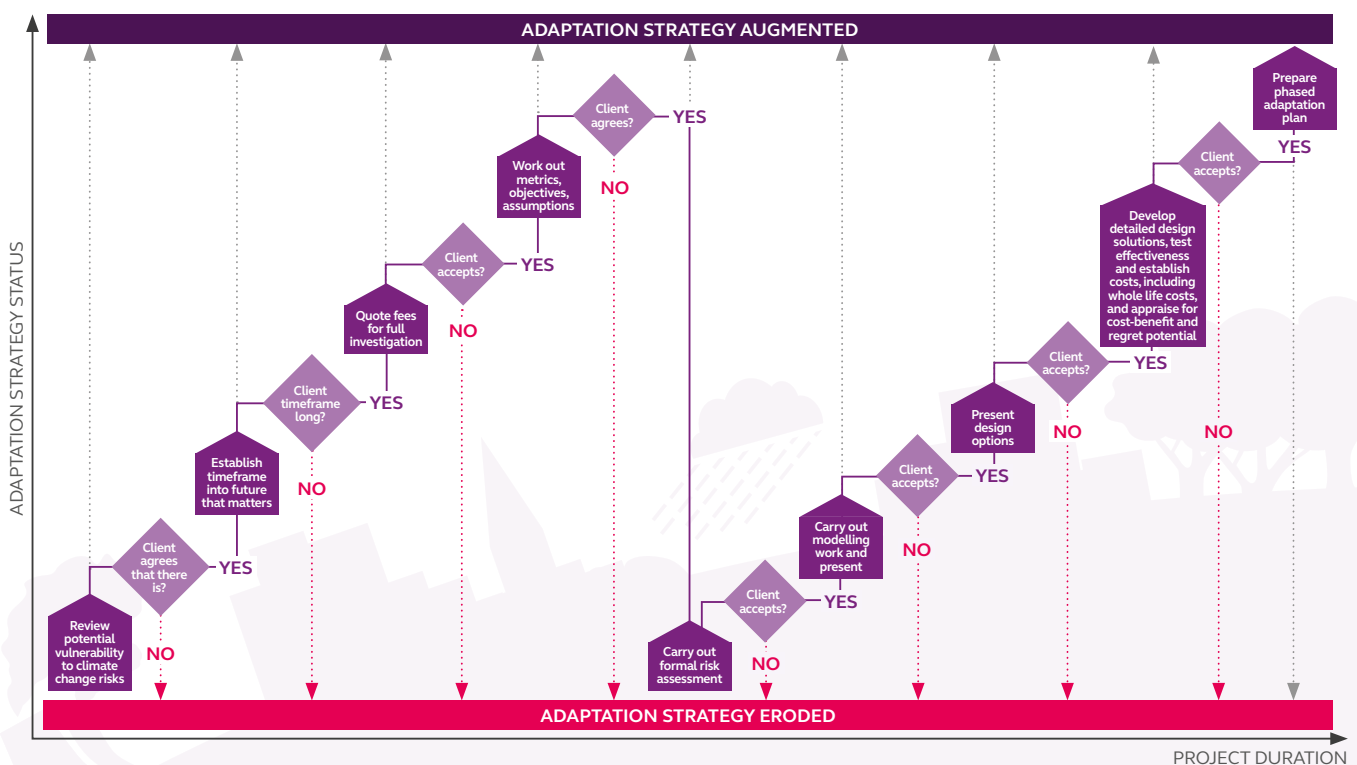
In other words, deliberately thinking through the implications of changing climate is new, different from anything previously experienced. In advance of mainstreaming, building designers need to draw on first-principles thinking that is not part of common practice. Agreeing what future weather data to use, taking account of the building type and clients' needs over time, is not part of the standard service (even if some clients assume that it should be). Answering a brief in the context of a changing climate requires a change of mind-set and expanded thinking.

The core competencies required for designing buildings capable of adapting to climate change involve gathering together information of the right sort in the right way to be able to support design decisions confidently or to make robust, clear and well-founded recommendations that allow clients to make rational investment decisions.

“Thinking through implications of climate change is different from anything previously experienced.”

The substantively new competencies for building designers are:

- having an overarching strategic understanding of the key (climate science) issues
- having to modify familiar practice to accommodate new (weather) data
- handling inherently uncertain data (based on probabilities)
- working without the safety net of guiding standards or regulations.



Graph 5: Gateways to a robust adaptation strategy.

Designer actions – arrow boxes pointing upwards – progressively augment the adaptation strategy, leading to a series of recommendations that are either accepted or rejected by clients – diamonds.



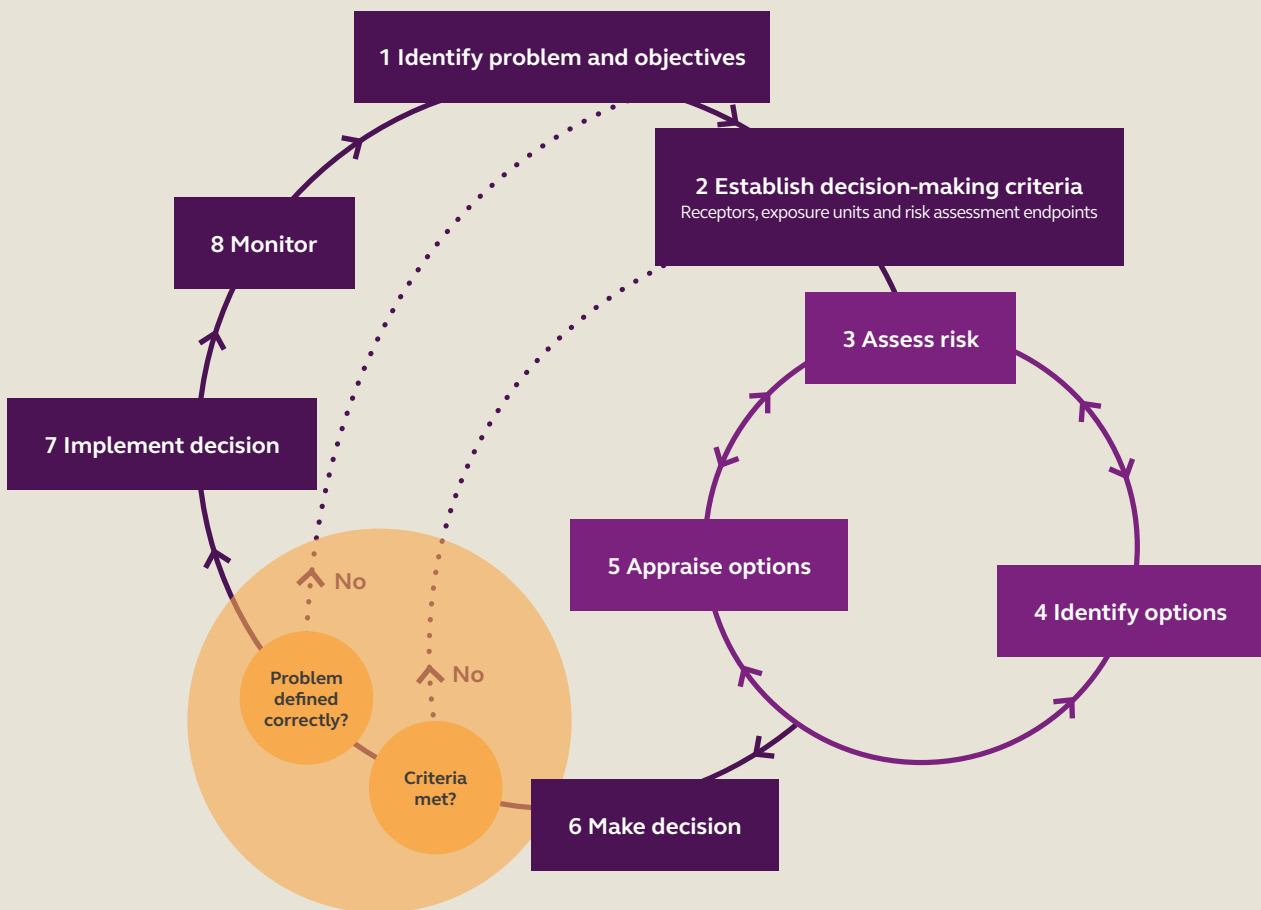
## The UKCIP Adaptation Wizard<sup>72</sup>

UKCIP sets out a model procedure for organisations to work out their vulnerability to climate change hazards and how to go about adapting. Called the Adaptation Wizard, it is a step-by-step process based on standard decision-making and risk principles and as such is the de facto starting point for would-be construction clients. The key stages of the process are:

- identify the problem and objectives
- establish your risk tolerance level and decision-making criteria
- identify and assess your risks

- identify a range of adaptation options
- appraise your adaptation options
- make a decision
- implement the decision
- monitor the decision and evaluate any new information.

It makes sense, therefore, for building designers to reflect the Wizard process in how they deliver their service.



UKCIP framework to support good decision-making

<sup>72</sup> See [www.ukcip.org.uk/wizard](http://www.ukcip.org.uk/wizard)

## Business competencies for adaptation

No two D4FC projects adopted precisely the same process but they did typically follow the UKCIP's Adaptation Wizard framework (see text box on previous page) to some extent (see Table 2), depending on the type of building and client, how advanced the design was when they started, and a number of other factors. The Innovate UK competition programme stipulated a risk-assessment approach, and it is likely that this impacted on how designers went about their work. However, despite the variety seen in the projects, it is unclear what alternative approaches there are.

UKCIP stage	PROJECTS		
	ENVIRONMENTAL SUSTAINABILITY INSTITUTE	ST FAITH'S SCHOOL	CLIFTONVILLE
<b>1 Identify problem and objectives</b>		Comprehensive building portfolio review Set up an Adaptation Advisory Team involving key consultants and experts Set project targets	
<b>2 Establish decision-making criteria – receptors, exposures units and risk assessment endpoints</b>	Site analysis	Assess priorities, potentials and cost benefits	<ul style="list-style-type: none"> <li>• Gething Risks (see Section 2)</li> <li>• Non-Gething Risks</li> <li>• Prometheus Weather Data and dynamic thermal analysis</li> </ul>
<b>3 Assess risk</b>	Risk assessment, informed by Gething Risks, UKCP09, Prometheus Site Weather Data.		Risk assessment
<b>4 Identify options</b>	Design options appraisal: comfort, water, construction, landscape  CRITICAL CLIENT INPUT  Detailed investigation phase: Keeping cool, external comfort, keeping warm; water conservation; flooding and drainage; landscape; construction	Develop a masterplan for adaptation work	Options appraisal <ul style="list-style-type: none"> <li>• Decision making matrix - weighting priorities</li> <li>• Key focus areas</li> <li>• of solutions</li> <li>• Cost benefit analysis</li> </ul>
<b>5 Appraise options</b>	Whole life costing exercise, informed by capital cost data; impact of comfort on productivity; current and projected fuel costs	Set up a workable adaptation strategy for each building whilst keeping the overall project target in mind  Adapt the building adaptation strategy as the project develops	SWOT analysis <ul style="list-style-type: none"> <li>• Strengths, weaknesses, opportunities and threats of each solution</li> </ul>
<b>6 Make decision</b>	Recommendations: reject; implement now; implement in future  CRITICAL CLIENT INPUT	Devise a building-specific adaptation plan	Decision to take to detailed design
<b>7 Implement decision</b>	Produce adaptation plans		
<b>8 Monitor</b>	Review adaptation plans regularly		

**Table 2:** Seven different D4FC approaches to adaptation compared to the UKCIP framework reveal a relatively faithful if not uniform fit.

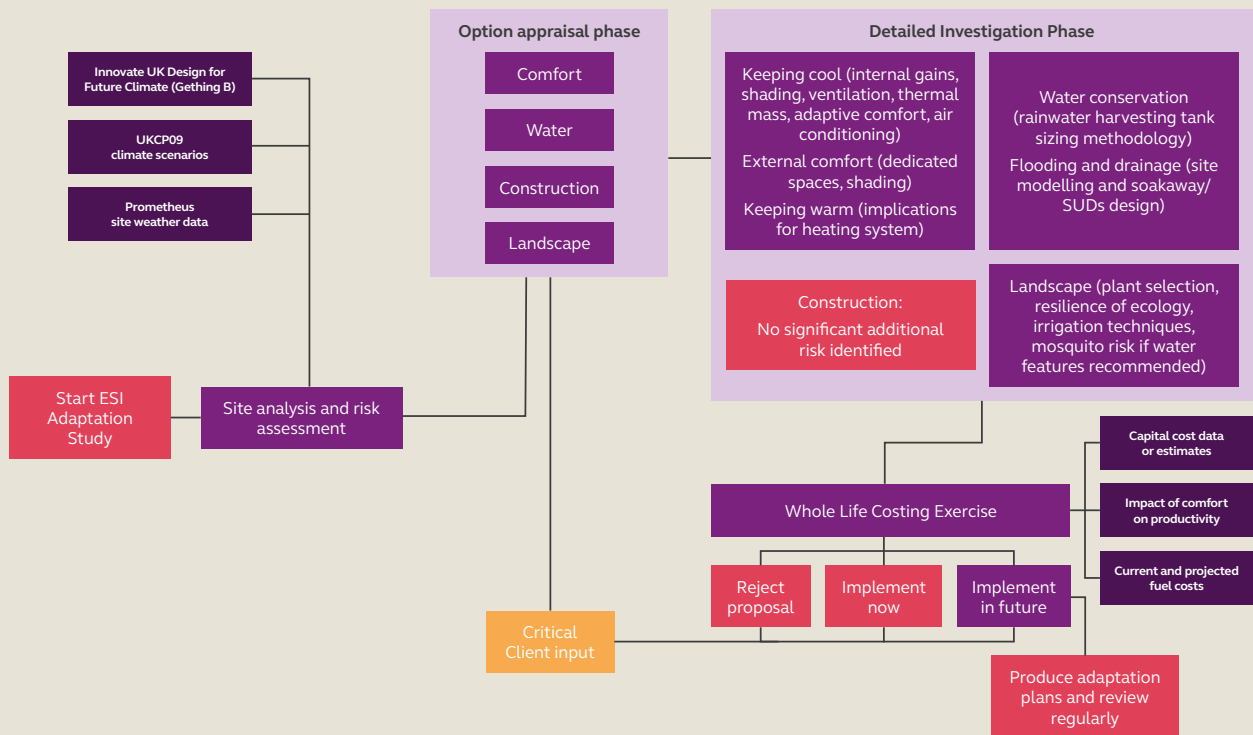
PROJECTS			
BETWS COLLIERY WASHERY RETAIL/ RESIDENTIAL	UNIVERSITY OF SHEFFIELD ENGINEERING GRADUATE SCHOOL	NORTH WEST CAMBRIDGE DEVELOPMENT	NEW ENGLAND QUARTER, BRIGHTON
Launch: Step 1: pre-start meeting and complete review of project in light of progress to case study project since bid submission.		Baseline assessment of design proposals	
Risk assessment: Step 2: establish an authoritative typology of frame and cladding property Step 3: devise a climate change risk assessment framework.	Assessment of impacts Appraise original building design	Scoping	Risk assessment
Step 4: use framework as a coarse sieve to assess typology Step 5: review conclusions and review scope of options to be considered in next stages Design: Step 6a: using the result from step 3, preliminary design options with further resilience features or adaption strategies and review Step 6b: continue work on design options	Develop alternative building designs Investigate effectiveness of alterations Examine facade options	Scenario analysis	Options appraisal
CBA: Step 7: appraise options together with the stage C scheme, using a more comprehensive framework than step 3.	Understand cost implications	Cost benefit analysis	Detailed design
Apply options to case study: Step 8: using analysis from step 7, client to decide on which options to. Process concluded with team workshop.		Final reporting	Cost assessment
Review: step 9: conclusions about (a) cost and benefit; (b) risk and fundability. Discuss applicability of case study evidence to the whole field of similar property and make recommendations			Business planning and reporting
Next steps: step 10: develop recommendations for a wiki-style knowledge centre.			

## Business competencies for adaptation

### Adaptation workflow

The team for the Environmental Sustainability Institute set out their process in a flowchart based on Bill Gething's adaptation matrixes. General steps are shown as light purple rectangles, start/end processes as red rectangles, key data sources as dark purple rectangles, and key client input as an orange box.

It succinctly encapsulates the generic process for developing an adaptation strategy.



### Engagement and negotiation

**The D4FC design teams found that establishing a common understanding early was an important key to success.**

The Church View team used an initial ‘bunker day’ to get the design team, some experts and the client together to discuss the issues.

The Edge Lane team used existing BREEAM workshops to move adaptation into the mainstream design, and recommended that adaptation should be on the project team meeting agenda while the brief is being developed.

The Glanford Retail Park team also used ‘focus sessions’ with the project design team to familiarise them with the concept of climate change adaptation and brainstorm possible innovations and strategies. They found that including adaptation in regular design team workshops maintained buy-in and had the added benefit of enabling:

“Greater creativity and an understanding of the wider win-win approaches to some of the initiatives, for example, the combined energy-water-biodiversity benefits that come from certain flood adaptation mechanisms.”

For engaging with the project team, the Great Ormond Street Hospital team found face-to-face round-table discussions very valuable:

“We found that having a discussion around the issues a much more effective method of upskilling everyone, rather than directing people to websites and reports, including our own.”

The Great Ormond Street Hospital team formalised initial findings with a report that identified the climate change risks, considered various design or strategic responses and included a desktop review of ideas worthy of further investigation:

“The report will be reviewed by the client to help ensure that the initiatives with the most potential to be included in the building’s actual climate change adaptation strategy progress to the feasibility and cost-benefit stages.”



**D4FC:** Refurbished incubator for creative and media industries, Church View, Doncaster



## Business competencies for adaptation

### Engagement and negotiation: agreeing parameters and assumptions

There are many sources of data to inform design work to take account of climate change – UKCP09, PROMETHEUS, Environment Agency flood maps, and so on – available for analysis and agreeing parameters, each with its own strengths and weaknesses. Similarly, there are several different tools available for their analysis. The D4FC teams found it helpful to agree on which parameters they would use as early as possible. The Co-operative head office report said:

“The detailed review and agreement early on with the team with regards to which climate scenarios would be assessed has been beneficial. This has helped in assessing the key problematic areas and the profiles of change, rather than using valuable resource for extensive data management (for example using IES thermal modelling and other tools).”

As many of the project teams discovered, using the climate data for building design often depends on making assumptions and interpreting by opinion rather than by any more scientific method.

“Where possible the analysis is quantitative, but the scoping nature of this section means that many factors are treated qualitatively.”

(North West Cambridge Development report.)

“Likelihoods were based on source climate data, engagement with the Walker Institute, region specific studies and site assessments, and ultimately reached through consensus.”

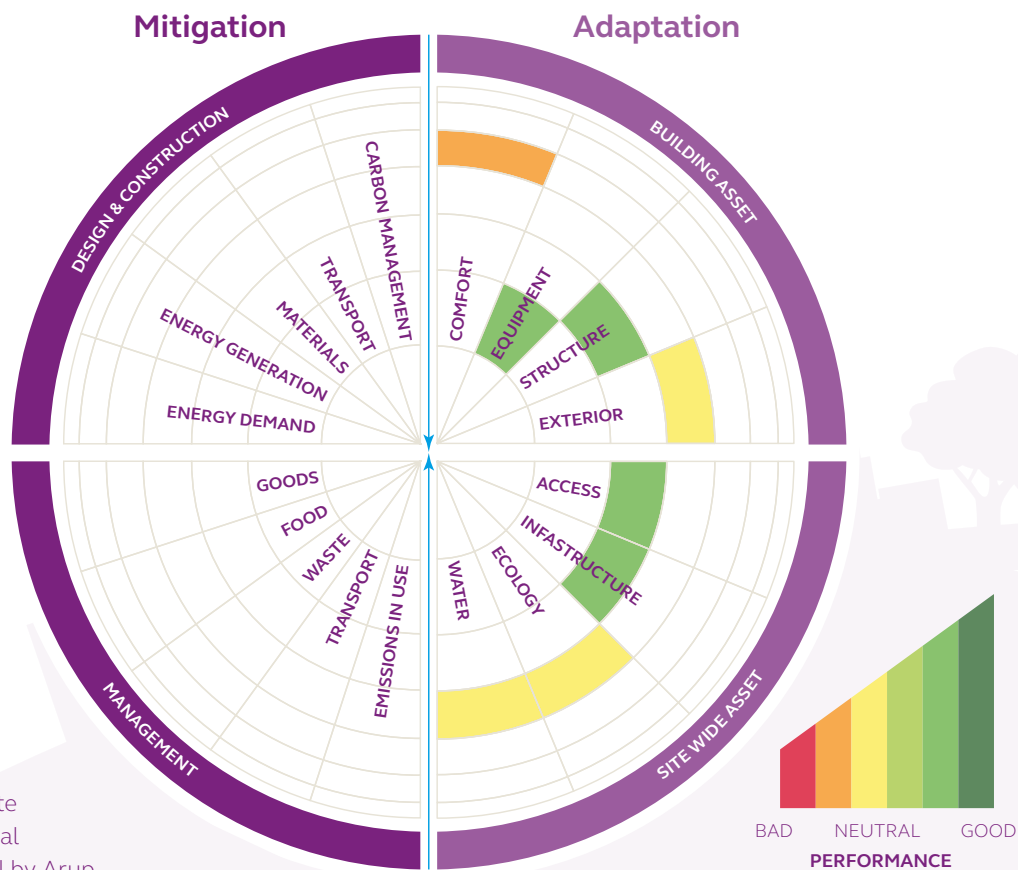
(Glanford Retail Park report.)

Assumptions also had to be made in calculating payback, particularly for the price of energy in the future.

“We used assumptions relating to energy costs – simply using 5p/kWh for gas and 12p/kWh for electricity – to enable the cost comparison.”

(Cliftonville report.)

It was important to acknowledge this need for interpretation openly to the whole project team and, as far as possible, move forward on the basis of consensus. For example, the Glanford Retail Park team held workshops with stakeholders specifically to understand vulnerabilities and the thresholds at which damage might occur. Arup used their in-house Climate Change Appraisal Framework (CCAF) to guide building owners and the design team through a structured appraisal process for the University of Sheffield Engineering Graduate School (see Figure 3).



**Figure 3:** Climate Change Appraisal Framework Tool by Arup

The climate scenarios selected need a rationale involving educated guesses. As a local authority, the Cliftonville team had an enduring interest in their building and thus wanted to look into the deep future.

“The longevity and quality of build of the buildings in question is such that we anticipate the structures to still be in situ in 2080. Therefore, any financial modelling and business planning would need to take into account the effects of climate change at that point.”

Other teams had different priorities.



**D4FC:** Extra Care 4 Exeter facility

### Extra Care 4 Exeter: a rationale for selecting climate scenarios and thresholds

**Climate scenario:** To account for the fact that the ultimate users – older people – were very vulnerable to the effects of overheating, the design team decided to model using a 2080 scenario which took the design 70 years into the future. To counteract the increasing uncertainty in the data and the simple fact that 70 years is a long way off, they chose the 50th percentile – the median of the distribution of possible climate change.

**Flooding return periods:** The team carried out a strategic flood risk assessment for the scheme based on Environment Agency (EA) flood maps. In the absence of clear industry guidance about how climate change scenarios affect flooding, they used information provided by Exeter University for return periods, detailed as follows: a one-in-a-100-year event becomes a one-in-50-year event by 2080, a one-in-50-year event becomes a one-in-20-year event by 2080.

**Comfort thresholds:** The team found that there was not a universally agreed model to adopt when simulating domestic designs and in particular extra care facilities. The choices include Health Memorandum HTM 03-01<sup>73</sup>, CIBSE TM36<sup>74</sup>, a Passivhaus Institute definition, and adaptive comfort models such as those in BS EN 15251<sup>75</sup> and ASHRAE 55<sup>76</sup>. They sought a consensus from the client, design team and developer about which to adopt, based on an understanding of the risks in each.

<sup>73</sup> Department of Health. (2007). *Health Memorandum HTM 03-01. Specialised ventilation for healthcare premises*. London: TSO. [www.his.org.uk/files/4713/7907/0658/HTM\\_03-01\\_Part\\_A\\_Specialised\\_Ventilation\\_for\\_Healthcare\\_Premises.pdf](http://www.his.org.uk/files/4713/7907/0658/HTM_03-01_Part_A_Specialised_Ventilation_for_Healthcare_Premises.pdf)

<sup>74</sup> CIBSE. (2005). *Climate Change and the Indoor Environment: impacts and adaptation*.

<sup>75</sup> British Standards Institute. (2007). *BS EN 15251: Indoor environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics*.

<sup>76</sup> ASHRAE. (2013). *Standard 55-2013 Thermal Environmental Conditions for Human Occupancy*.

## Business competencies for adaptation

### Assessing the risks

**The general advice from the D4FC projects was to focus on identifying high risks early, and concentrate limited resources on them at the expense of less important risks.**

#### Assessing the risks: project management

**There is currently no prescribed industry standard for how to undertake a risk assessment for a site to account for the impacts of climate change. However, because it underpins all adaptation design and must co-ordinate with all the other design work, the process must be well-structured and properly managed.**

Although this fell to various members of the design teams in the D4FC projects, the expert panel felt that this process should logically be added to the project manager's scope of work – with input from all parties, including the client.

The Glanford Retail Park team also saw this stage as an opportunity to engage early with all influencing stakeholders, and not just the head client. They did so using a responsibility assignment (RACI) matrix – responsible, accountable, consulted and informed – to ensure that considering climate risk was part of the 'due diligence' and design process:

"You need a structure that allows for multi-stakeholder input. We came up with a RACI matrix to target who has responsibility for what. You've got to establish it as a briefing requirement."

Most of the D4FC teams depended on meetings that brought together clients, the main design team and those undertaking the adaptation study to make progress. There were a range of views on whether the meetings should be in addition to normal design team meetings, or part of them. The Extra Care 4 Exeter team argued strongly for the former:

"Workshops were separate from the usual design team meetings and therefore climate change design matters were not seen as a small part of a larger design team meeting."

On the other hand, the Sheffield Graduate School team argued:

"The most effective way of influencing the client to consider climate change adaptation aspects of building design is to embed adaptation considerations into the main design process."

Both approaches were successful in getting the client to adopt their recommendations.

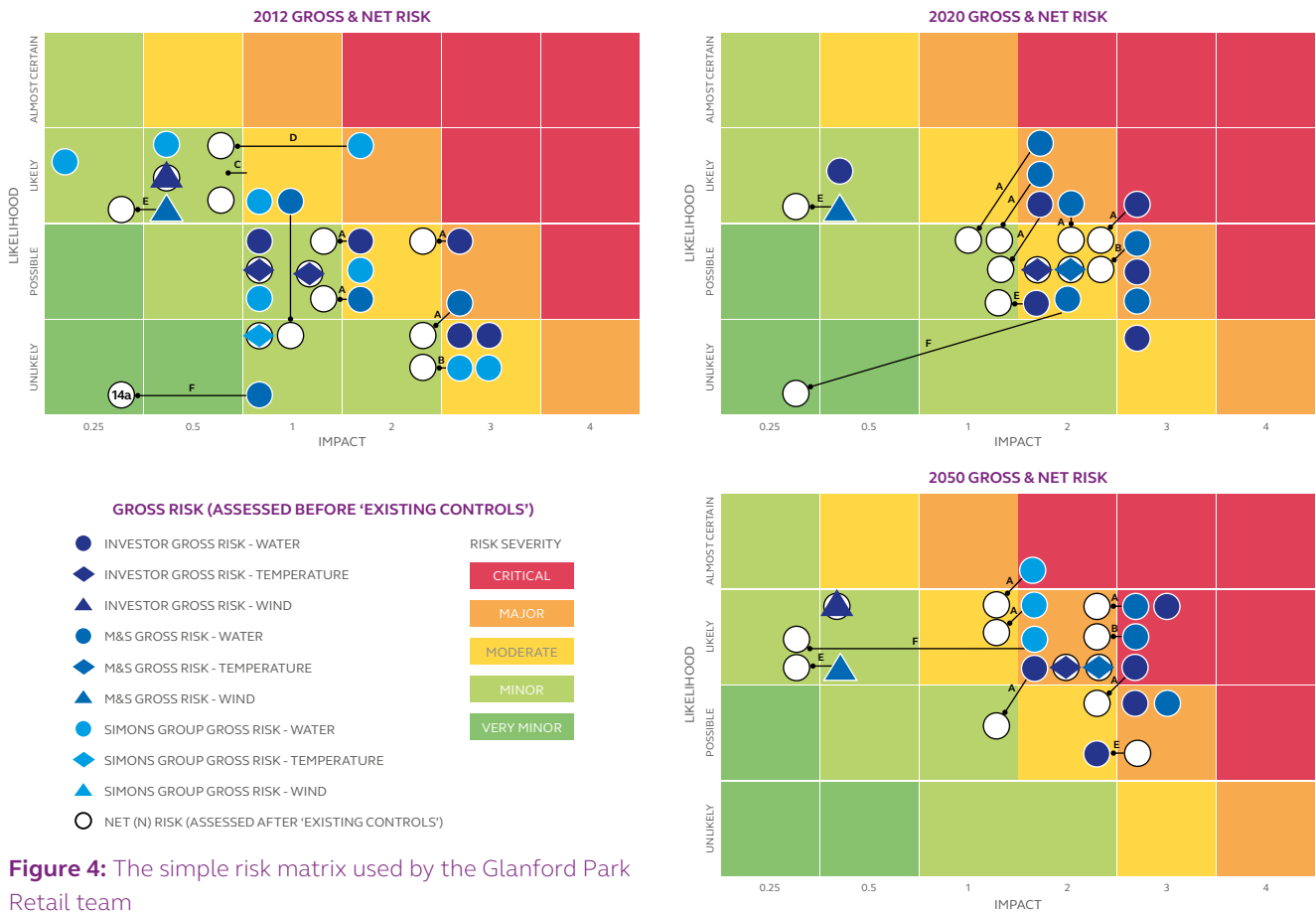
### Assessing the risks: rating risk

**Some teams assessed the value of adaptations against a baseline unadapted building.**

For the Environmental Sustainability Institute, the team agreed potential changes to the climate expressed in simple headline terms, for example, it will be 6°C warmer on average. They depended on their professional knowledge to work out how these might impact building performance and to shortlist candidate measures. This prepared them for more detailed numerical analysis of potential risk by seeing how potential design interventions would benefit the baseline unadapted building under future climate.

The Glanford Retail Park team recommended that stakeholder-specific risk tolerances were explored as early as possible. Their tactic was to scrutinise all the financial stakeholder's needs to maximise the building's resilience to future climate. They used a simple risk matrix plotting likelihood against impact for 2012, 2020 and 2050 to score and communicate gross and net risks to the three financial stakeholders – the investor, tenant (M&S), and contractor – see Figure 4.

## Business competencies for adaptation



The North West Cambridge Development project team used a similar matrix (figure 5 below) to establish a risk rating system.

Consequence \ Likelihood	Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Catastrophic (5)
A (almost certain)	L	M	H	X	X
B (likely)	L	M	M	H	X
C (moderate)	L	L	M	H	X
D (unlikely)	L	L	M	M	H
E (very unlikely)	L	L	L	M	M

**Figure 5:** Matrix used by North West Cambridge Development project team

Although it was not available in time for most of the D4FC projects, the Probabilistic Climate Profile (ProCliP) charts developed by the Chartered Institution of Building Services Engineers (CIBSE) (with UKCIP, Innovate UK and the Engineering and Physical Sciences Research Council) is a comparatively simple way to help clients and design teams agree parameters on which to base their climate-change strategy, and to select appropriate weather files for use in building analysis. (See text box on following page.)

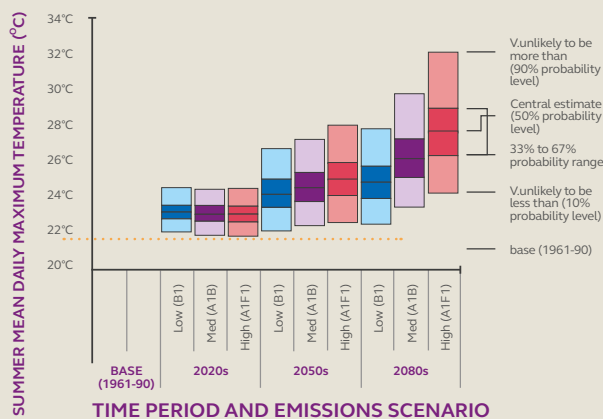


### Which climate? Probabilistic Climate Profile (ProCLiP) charts

CIBSE has produced a set of Probabilistic Climate Profile (ProCLiP) charts that present future climate data in a way that greatly assists the selection of appropriate design temperature and precipitation data for a project.

The charts, plus associated guidance, show values for the following climate variables for each of the three emission scenarios, and for three temporal periods (2020s, 2050s and 2080s) for the 14 locations for which current design data is also provided by CIBSE.

- Seasonal mean air temperature (winter, spring, summer, autumn)
- Daily minimum temperatures for winter
- Daily peak temperatures for summer
- Seasonal daily precipitation (winter, spring, summer, autumn)



**Figure 6:** ProCLiP of summer mean daily maximum temperature for London

Taking the summer mean daily maximum temperature for London as an example, the chart shows the baseline temperature (for the period 1961-90) as an orange dotted line (between 21 and 22° C) and the range of projected temperatures for the 2020s, 2050s and 2080s for the low (blue), medium (purple) and high (red) emissions scenarios.

The horizontal line across the middle of each bar is the 50th percentile value or central estimate; the darker section of each bar represents the 'likely' range (33% to 67% probability) of temperature and the lighter section of each bar shows the projected 'very likely' (10% to 90% probability) range. This example shows that, under the medium emissions scenario, it is 'very unlikely' that the summer mean daily maximum temperature in London will be less than about 23.5° C by the 2080s. The verbal descriptions used here are not qualitative but represent statistical ranges as shown.

The charts thus give an excellent overview of the range of values projected for a given variable and location as the century unfolds.

A number of factors might be considered in selecting appropriate data for a given project:

- time – the life span of the building or building element, maintenance periods etc
- vulnerability – of the building, its occupants or contents
- change – how sensitive the variable is to change over time
- emissions – likely trends in emissions
- client preference.

An alternative approach is simply to pick values and then consider the extent to which their use would constitute over-design at the start of the period under consideration, whether particular values represent thresholds beyond which a given strategy is unable to cope with and the (increasing) likelihood of a value representing under-design over time. The complexities are thus reduced simply to time alone (set in the context of the range of projected values over the century).

### Modelling

**Once the future climate scenarios have been selected and the climate risks have been identified, the D4FC teams modelled their buildings using corresponding weather data to see how they performed.**

This follows the normal practice of building engineering modelling but modified by loading different data. Ordinarily, dynamic simulation tools are used principally for retrospective energy performance verification. However, for the D4FC adaptation studies they were used earlier than is usual in the design process as prospective design aids for examining internal environmental conditions, requiring more interaction than normal between designers from different disciplines and regarded as a positive experience. The exploration of a range of options clearly requires more simulation runs to get a realistic idea of the distribution of weather impacts at different timescales and emissions scenarios than would be the case for simple regulatory compliance. At the extremes, the impacts are either insignificant or catastrophic. More usually, the outcomes allow fine-tuning of designs for the best overall result.

“That’s the value of modelling as a design tool rather than a compliance check.”  
(Expert panel member.)

Some members of the expert panel informing this report saw a more versatile, longer-lasting use for these models, suggesting that they should be retained to use to analyse performance post-completion and to establish the point at which further interventions are needed.

“Dynamic simulation tools are principally used to verify energy performance retrospectively.”

### Modelling: baseline comparisons

The techniques for assessing the effect of particular measures against a baseline building also involved many iterative simulations. In assessing the value of measures for thermal comfort, the Cliftonville team, for example, ran a baseline unadapted model against the control and 2080 weather data files, thereafter rerunning it several times to see the effect of adding each of the measures one by one on their own. Only then did they combine measures in simulations.

“In this way we could see their individual impact (and value) and also how they interacted once combined, prior to the application of cooling which would otherwise distort the outputs.”

Before modelling their building, the Extra Care 4 Exeter team ran a previously built model of a similar completed project using future weather data to understand the impacts of future weather on that design.

“This proved to be a valuable experience for the design team, as it enabled the team to understand the weather files at early stages in terms of overheating and design implications.”



**D4FC:** Great Ormond Street Hospital

## Business competencies for adaptation

### Modelling: worst-case scenarios

**Because limited resources need to be allocated efficiently, the relative complexity and time-consuming nature of some modelling techniques meant that on some projects only worst-case scenarios were modelled to test design thresholds.**

For example, the North West Cambridge Development team restricted their analysis of the thermal effects of wind-flow patterns around the site because of the complexity of computational fluid dynamics (albeit that this was a level of sophistication in modelling not used by most projects).

Dynamic computer simulations are not always the answer for assessing future climate risks. The North West Cambridge Development project recognised that the climate and their derived weather files are insufficient for detailed modelling of extremes, which is important when understanding building design limits.

“For some assessments such as flooding or overheating, it was felt that simple descriptions of expected extreme events would be more useful than derived weather files.”

Some D4FC teams saw the value in choosing high emissions climate scenarios at the higher end of the probabilistic range for their simulations to exaggerate climate effects for the purposes of teasing out vulnerabilities. The Betws Washery team, for example, chose a 2050 high emissions scenario with a 90% confidence interval because the buildings’ lifespans might not be more than 40 years.

“Statistically the desire was to avoid the masking of risk with a scale of data that was too fine grain.”

### Modelling: handling data

**The weather data used were mostly from PROMETHEUS<sup>78</sup>, which are derived from UKCP09, although some chose to use older CIBSE files, which are based on the previous climate projections, known as UKCP02.**

(Arup also used a beta version of forthcoming CIBSE probabilistic weather files derived from the 2009 projections and two projects used data from the Manchester University

COPSE [Co-incident Probabilistic climate change weather data for a Sustainable Environment]<sup>79</sup> project, also based on the 2009 projections.)

Running multiple simulations for different climates and measures generates a daunting volume of data, which is a very real problem. Agreeing the exact modelling runs, the relationships to be examined, the metrics used and how the information is to be presented allows for an efficient management of the risk assessment and design process:

“Making these decisions before seeing the data can be difficult and does carry some risk but the benefits are a significantly more efficient analysis process.”

(University of Sheffield Engineering Graduate School report)

The Great Ormond Street Hospital team found that, although positive from a full disclosure point of view, too much data makes it difficult for the client to interpret their meaning.

“Often the message got lost in the detail of the reporting. Retrospectively we would be more selective in the analysis we undertake and even more selective in what we show to the client.”

While all of the D4FC teams found dynamic simulation modelling software useful, they needed a bit of creativity to model unconventional things such as manual control, tree shade, the effect of water and transpiration, phase-change materials, ceiling fans, green roofs, and the albedo effect. Although their final reports show that they found various workarounds for some of these issues, the general message was that expanding the capabilities of the modelling software to deal with as many of these issues as possible would assist designers in exploring a fuller range of potential strategies and produce more consistent results.

For environmental variables for which future climate data was not available, some D4FC teams elected not to attempt to consider how these might change. For example, since they are not in the UK climate projections, many teams did not consider the effects of wind. Those who did not, took advice from BRE guidance (Digest 499<sup>80</sup> and GBG 63<sup>81</sup>), while the Great Ormond Street Hospital team relied on scenarios derived from historic data.

<sup>78</sup> Developed by the University of Exeter, PROMETHEUS was a multi-disciplinary EPSRC-funded project. It aimed to create probabilistic future reference years using the output of UKCP09, identify the problems new buildings face as a result of climate change using physics based models, and help the building sector adapt to the challenges of climate change. <http://emps.exeter.ac.uk/research/energy-environment/cee/research/prometheus/>

<sup>79</sup> Developed by Manchester University, Co-incident Probabilistic climate change weather data for a Sustainable Environment (COPSE) developed a methodology for providing the weather data that the building community needs for making decisions about new and existing buildings. [www.copse.manchester.ac.uk/index.htm](http://www.copse.manchester.ac.uk/index.htm)

<sup>80</sup> BRE. (2006). *Digest 499: Designing roofs for climate change. Modifications to good practice guidance*. Bracknell: BRE.

<sup>81</sup> BRE. (2004). *Good Building Guide 63: Climate change: impact on building design and construction*. Bracknell: BRE.

### Uncertainty

Uncertainty is possibly the overriding challenge for building designers taking on adaptation work, a factor that affects every piece of information in a way that tends to disincentivise clients. It can seem that the uncertainties are overwhelming and that steering a defensible path through them is an almost impossible task. There is some suspicion that the level of uncertainty is bigger than the effect that building designers are looking at.

“After timing, the most critical factor that can result in unsuccessful outcomes that is less under our control in our opinion is uncertainty in research methods and approaches, the climate science, the technology and innovation, and the surrounding economic and political climate.”

(Environmental Sustainability Institute report)

It is very difficult to communicate this uncertainty in ways that make it easy for the client to understand and accept the risks. A senior engineer member of the expert panel said:

“We need to *try* to communicate uncertainty. It’s presenting with ranges rather than fixed numbers, with graphical ways of representing the blurriness of it, to not imply that it’s certain but it’s somewhere in this range rather than somewhere in that range.”

Scenarios are an established way of handling and communicating uncertain futures. The Glanford Retail Park team knew their site would flood but not by how much. In the absence of robust probabilistic data for the flood risk on their site, they switched to a scenario-based assessment. This involved identifying the thresholds at which there were quantitatively assessed step-changes in severity of business impacts. What could be handled by a member of staff with a bucket and a mop? What would force the M&S store to shut down? These could then be presented to stakeholders as a range of scenarios in terms they could understand to determine how they wanted to ‘insure against’ the impacts. Of course, the critical missing factor was the probability of occurrence, which was based on historical records for the neighbourhood (and not the future). Nonetheless, the system was helpful.

“That was the only way to make it real to the client. It then became less dependent on justifying recommendations around what the science is telling you or what the available information is out there, which doesn’t have the granularity to drive an investment decision at the level of a site.”

Another way to deal with uncertainty is to monitor the building’s performance to fine-tune adaptation plans over time.

“For a building to be adapted to climate change in the longer term (i.e. comfortable, water efficient and robust), a regular review of the building’s performance would be necessary.”

(Environmental Sustainability Institute report)

The degree of uncertainty introduced by the modelling itself is highlighted in a research paper that used different future weather datasets for the same building model. It revealed that tests using files from PROMETHEUS, CIBSE, and COPSE gave different results. In a probabilistic world, they can all be right even though they yield different answers. It is also common knowledge that different dynamic simulation tools can produce quite different results for the same building. It is possible that we are dancing on the head of a pin here and the detailed answers are not critical. Given the compound inaccuracies involved in the whole process, it is inevitable that there will be differences between different methodologies let alone the variation in the way buildings are actually used. This highlights the need to retain a sense of proportion in the face of dealing with large amounts of apparently definitive information and recognise that process can only give an indication of likely effects rather than pinpoint accuracy.

That said, given the evidence of past and future climate change, continuing to use current regulations and standards based on historic measurement will clearly not provide a better guide to future performance. As a member of the expert panel said:

“The limitations in modelling based on current guidance must be mentioned. We are using out of date data to design buildings.”

<sup>82</sup> See Gupta, R. G. (2013). *Evaluative application of UKCP09-based downscaled future weather years to simulate overheating risk in typical English homes. Structural Survey, 31(4).*

## Business competencies for adaptation

### Options appraisal

#### Options appraisal: visual information

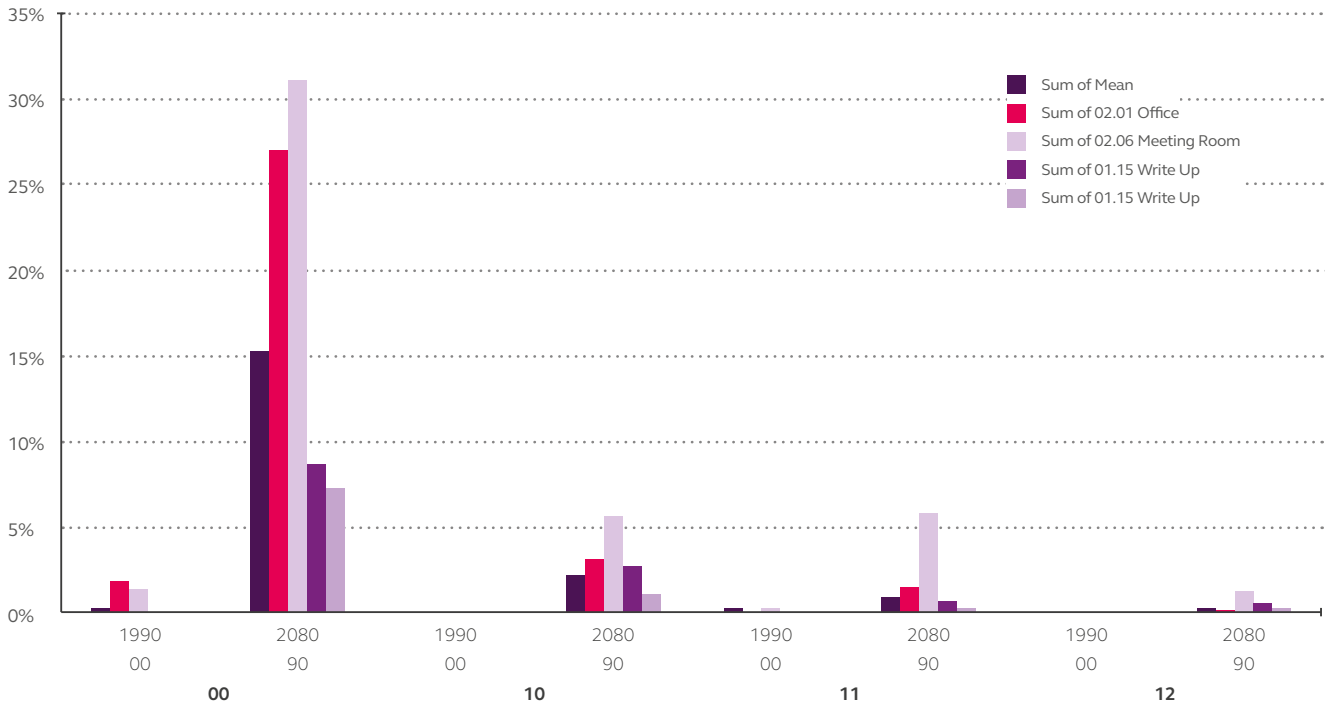
The D4FC teams all recommended that design options are clearly and accessibly illustrated. For example, Extra Care 4 Exeter used Sketchup<sup>83</sup> to visualise modelling results in 3D, the team working on the London School of Hygiene and Tropical Medicine developed ‘heat maps’ to represent room-by-room overheating data, and the Harris Academy team produced a number of what they called ‘optioneering’ studies to communicate their design intent.

“Our graphics were successfully used, and very simple. They show a timeline or the maintenance cycle, which is very important and was a great door-opener.”

(Innovate UK, 2013)



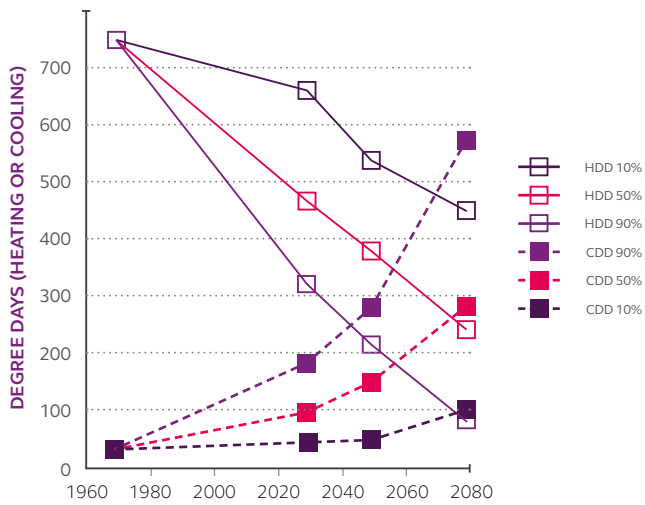
D4FC: Harris Academy



**Figure 7:** Graph showing % occupied hours above 28°C for an unadopted building (00), passively adopted (10), comfort cooled (11) and passive + comfort control (12) under current climate and in 2080s 90% for a range of rooms denoted by different colour bars, with dark purple being the average result across the building. Graphic by Extra Care 4 Exeter.

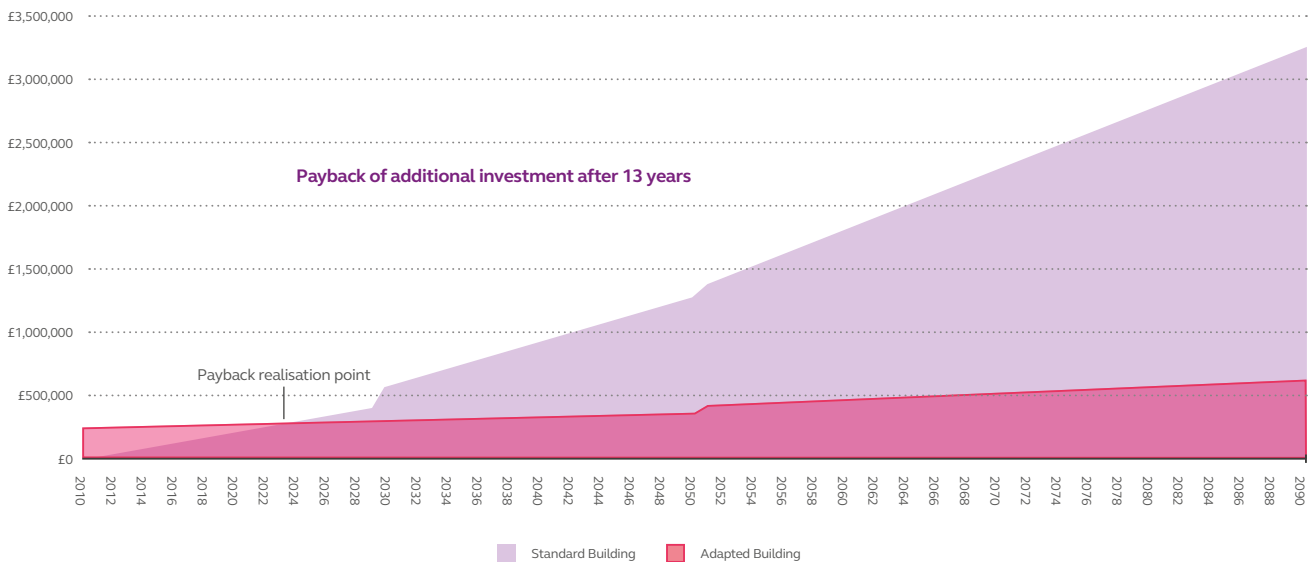
<sup>83</sup> See [www.sketchup.com/products/sketchup-pro](http://www.sketchup.com/products/sketchup-pro)





HDD = heating degree days  
 CDD = cooling degree days  
 Emission scenarios = high (90) medium (50) and low (10)

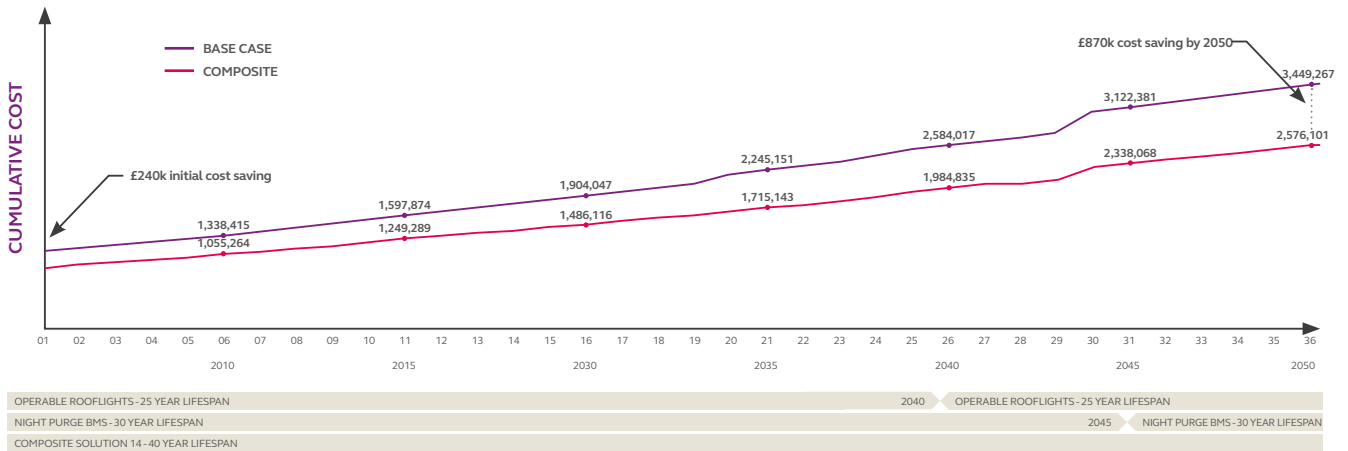
**Figure 8:** Plots of heating and cooling degree days (HDD and CDD) showing the range of uncertainty in the climate projections (Data shown for the site; HDD base temperature 10.5°C, CDD base temperature 18°C). Graphic by Extra Care 4 Exeter.



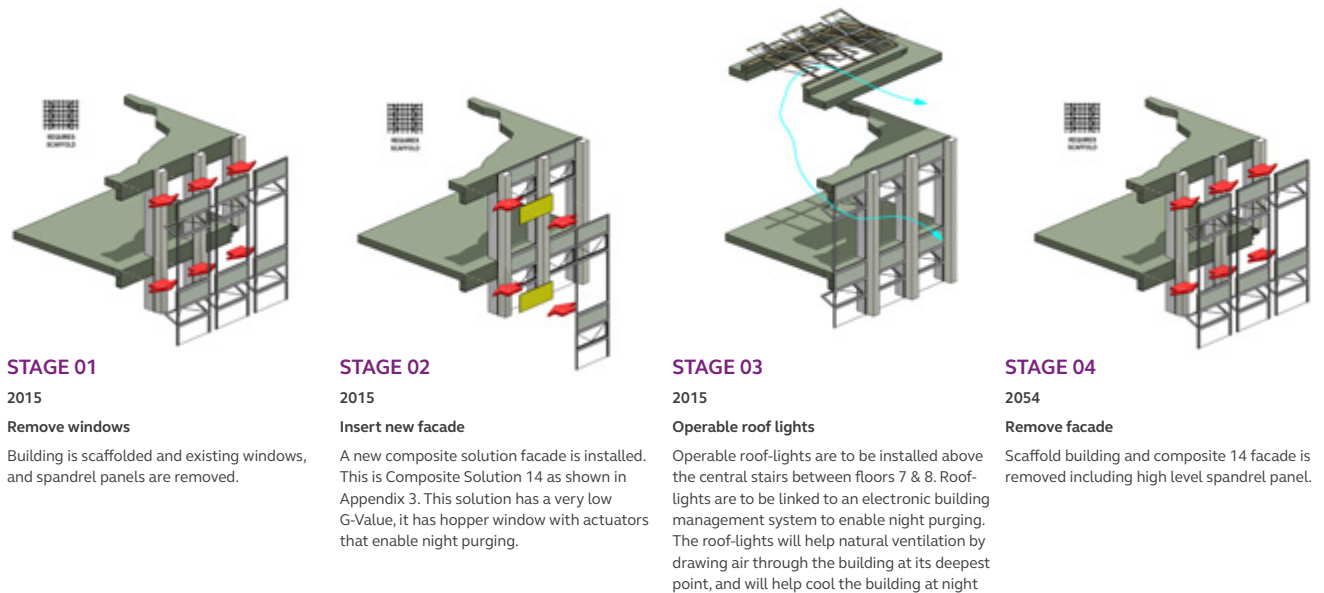
**Figure 9:** The graph shows the cumulative costs for standard construction and for a building incorporating adaptation measures for the Extra Care 4 Exeter project. After 13 years the additional construction cost of the adapted building will be paid for by savings in energy costs as compared with standard construction.

# Business competencies for adaptation

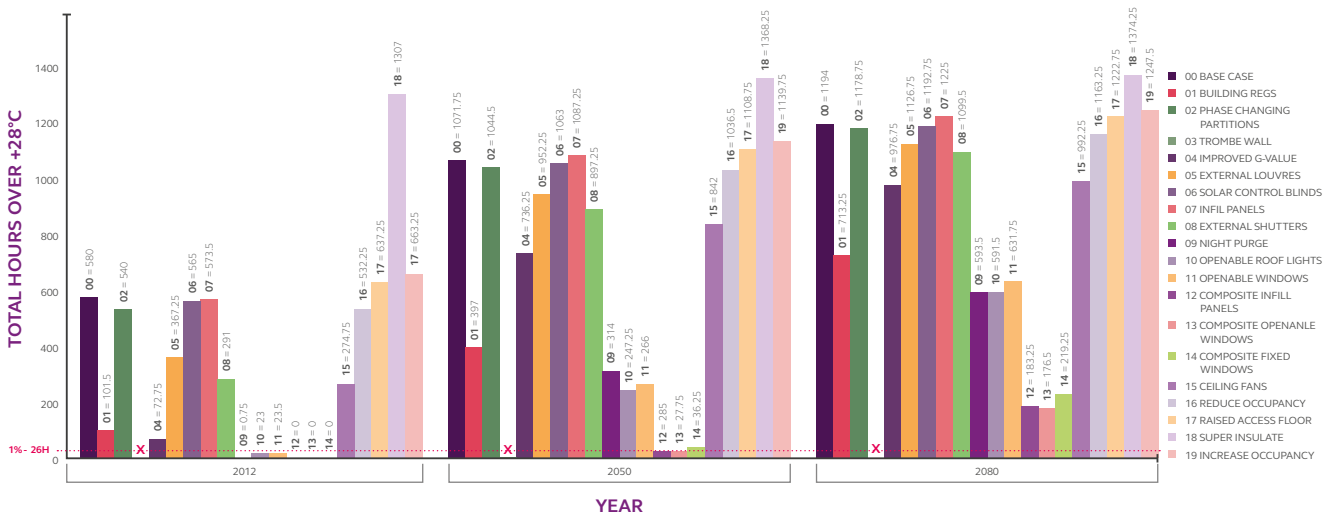
## Adaptation timeline (Management B4 Fabric)



**Figure 10:** This graph produced by the Management B4 Fabric project shows the whole-life cost and compares the baseline project with the adapted composite project.



**Figure 11:** These images are an extract from a larger graphic produced by the Management B4 Fabric project. They show staged adaptation processes along the timeline.



**Figure 12:** This further graphic from the Management B4 Fabric project shows the effect on overheating when a range of measures are applied to the baseline project.



**Figure 13:** Visualisation of ExtraCare 4 Exeter

## Business competencies for adaptation

### Options appraisal: evaluating design measures

The D4FC projects teams assessed design options in the main by adopting the UKCIP Adaptation Wizard's decision-making method that categorises interventions in the following ways:

- **no regret** – provides a 'best outcome' regardless of climate change scenarios
- **win-win** – measures that should be implemented for reasons not directly motivated by the need to adapt to climate change
- **low regret** – measures considered to have very low cost implications taking into account uncertainties of scale of future climate change
- **under-adaptation** – measures that are not sufficient to deal with likely climate change projections
- **over-adaptation** – measures with high investment cost but limited benefit.

The D4FC teams tailored these categories to their unique project circumstances. As a developer-led project where the anchor tenant was known, the Glanford Retail Park team appraised measures using simple categories:

- **no regrets/quick win** – adaptation options that would be justified under all plausible future scenarios, including the absence of man-made climate change, and which require low or moderate levels of investment
- **low regrets** – adaptation options in which the associated costs are relatively low and for which the benefits, although primarily realised under projected future climate change, may be relatively large
- **high regrets** – involves decisions on large-scale investment with high irreversibility and potential impacts on others
- **inconclusive** – adaptation options that cannot be evaluated without further financial assessment and/or piloting.

The Co-operative head office team rated their measures against many more factors, reflecting the client's ecobrand philosophy:

- **effectiveness** – will the actions meet the objectives?
- **efficiency** – do the benefits exceed the costs?
- **equity** – the action should not adversely affect other areas or vulnerable groups
- **flexibility** – is it flexible and will it allow for adjustments and incremental implementation?
- **sustainability** – does it contribute to sustainability objectives, and are they themselves sustainable?
- **practical** – can the action be implemented on relevant timescales?
- **legitimacy** – is it politically and socially acceptable?
- **urgency** – how soon could it be implemented?
- **costs** – consider social and environmental costs, not just economic
- **robust** – is the option robust under a range of future climate projections?
- **synergies** / coherence with other strategic objectives – does it help to achieve other objectives?

For the Brighton Housing team, however, the priority was financial viability, and so the team looked for their measures to demonstrate this characteristic in terms of:

- being **very low or zero-cost measures**, such as exposed concrete finishes
- **adding value** to the building/dwelling/asset (through higher sales values because they are more desirable or enable greater usability etc)
- **reducing maintenance costs** over their lifetime
- facilitating planning permission and therefore **reducing costs associated with development**.



Even for a building that needed to be ‘living proof’ of sustainability, the Environmental Sustainability Institute team reported that there was an ‘unwritten understanding’ that measures for inclusion now would be included where they were at marginal/low cost/quick payback or where it could also help with other requirements. They were able to conclude that in their project critical success factors for implementation included measures:

- where changes now were at **zero or very low cost**
- where there were **strong regulatory requirements**, ie to meet planning requirements
- that resulted in **additional benefit now**
- where recommendations were made for **future interventions**
- that limited **disruption**
- where there was **funding in place** to undertake analyses.

The team working on the developer-led Betws Washery project subtly took account of the various stakeholders’ priorities in assessing their measures, taking particular notice of the ‘demand-side’, i.e. unknown retail tenants. They expressed their categories as recommendations.

**1. Marginal cost with investment value:** Designed to appeal directly to the developer without any need to refer to other demand-side parties because practically all the adaptations produce added value with a negligible cost implication, such as a reflective roof. They therefore do not need justification via cost-benefit analysis.

**2. Modest cost with investment value:** Adaptations that do incur cost, which although modest as a proportion of the total capital cost, would be sufficient to make them vulnerable to cost engineering. Again the recommendation is designed to appeal to the developer without reference to other demand-side parties.

**3. Developer recommendation to tenant:** Adaptations that solely affect fit-out and are of no financial interest to the developer or investor. The benefits are very direct because they affect the operational costs of the building. The question is not so much whether they should be done but when. The vulnerabilities exposed by climate change are in the long-term and, because the major re-fit cycle is approximately 10 years, it makes no sense to implement them now unless there are co-benefits to warrant it.

**4. With potential but subject to further R&D:** Adaptations that have potential but need to be explored with more R&D. Although initially directed at the developer client, these are more focused on the supply side of the industry – designers/engineers, and manufacturers. Can good solutions be developed to offer to investors and tenants? The development and take-up of these potential adaptations in this category is not simply a technical matter because they straddle the divide between passive built-in measures that the investor pays for and the fit-out plant that the tenant is responsible for. Therefore, the solutions also need to address procurement, financing and lease questions.

**5. Developer choice:** Measures that bring so many benefits that they cannot be ignored but they either raise difficult issues, or are too expensive to be easily recommended. They all therefore fall into a position where the developer would need to champion the cause. As such they are presented as optional extras.



### How clients assess adaptation strategies

A client will only be able to assess the value of any recommended measures rationally if they understand three things:

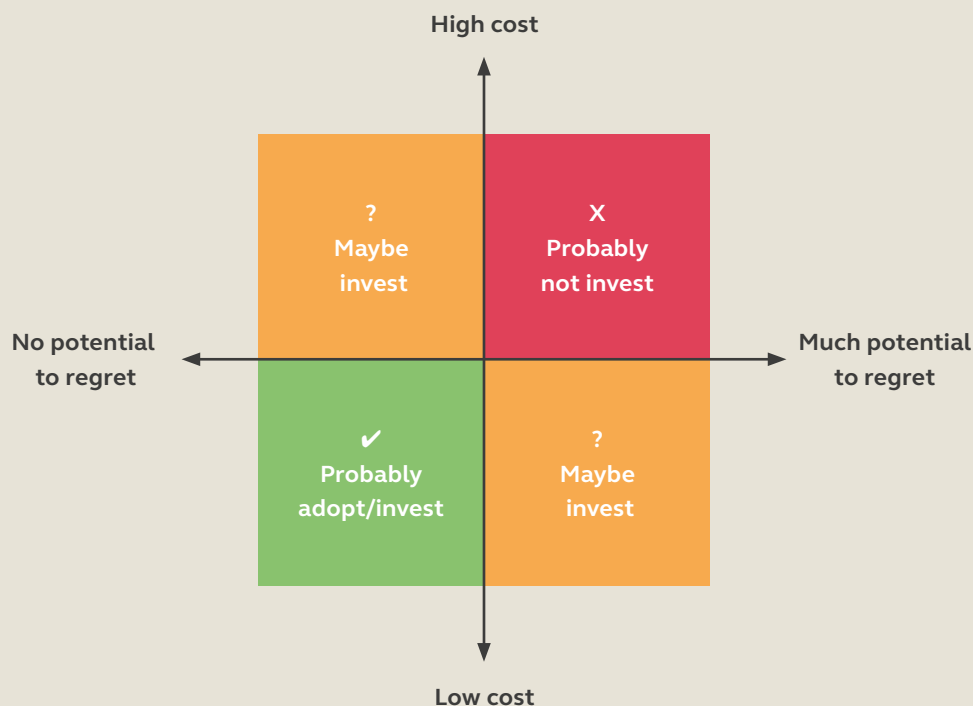
1. **the risks:** how risks might impact on the building over time
2. **the cost-benefit of the measures:** this usually means calculating the whole-life cost, i.e. comparing options and their associated income streams and capital, procurement, opportunity and future costs over a period of time. It also includes benefits with no financial dimension
3. **the potential for regret:** after a cost-benefit analysis, a final check on whether a measure is a good bet.

It is worth noting that there is little correlation between the capital cost of a measure and its effectiveness – as determined in modelling<sup>84</sup>. For example, the University of Sheffield Engineering Graduate School team found that

the cost of a measure bore no relationship to its ability to reduce the percentage of occupied hours when the building would overheat. This is an important point and paves the way for the concept of ‘win-win’ measures.

#### Regret potential

The literature on what kinds of measures are likely to be a good bet for clients uses the concept of ‘regret’ in the context of capital expenditure. The worst kinds of investments that a client can make are in large capital expenditures that they end up regretting – i.e. that damage their return on investment, however that is calculated. Clearly, then, the best kind of investment is in adaptations that are exceptionally unlikely to be regretted and that cost nothing. These are two opposite parts of a decision-making quadrant illustrated in Figure 14. The other parts of the quadrant – high cost/low regrets, and low cost/high regrets – make decisions slightly harder.



**Figure 14:** Matrix for making decisions about investing in adaptation measures using the concept of regret potential.

<sup>84</sup> Bill Gething, Katie Puckett. (2013). *Design for Climate Change*. London: RIBA Publishing.

### How to assess the potential for regret

The concept of ‘regret potential’ is composed of a number of variables and is therefore not easy to define. These variables are set out as a list of prompts in Figure 15. Note that they are on a scale from very positive to very negative, with many points in between and that, depending on the measure being assessed, they are difficult to quantify objectively. Also, depending on the circumstances, they will be differently weighted by clients. Nonetheless, if the answer to all the questions in the list is more ‘yes’ than ‘no’, then the measure is less likely to be regretted by the client.

Variables	Yes	Partly	No
The measure goes on protecting as the risk changes over the building’s planned life	Green	Orange	Red
The measure uses a proven, robust and enduring technology	Green	Orange	Red
The measure brings many benefits other than adaptation	Green	Orange	Red
The measure does not adversely affect the performance of the rest of the design	Green	Orange	Red
The measure is easy to alter after it is built	Green	Orange	Red
The measure helps to meet regulations and planning conditions	Green	Orange	Red
The measure is independent of a larger adaptation system comprising other measures	Green	Orange	Red

**Figure 15:** Simple list of prompts showing the variables that affect whether a measure has the potential to be regretted. Note: the term ‘measure’ here means a design intervention aimed at adapting the building to climate change risks.

### Reasons to include adaptation measures immediately

Designing-in a given adaptation measure to the building from day one is worth recommending if:

- the risks are likely to be present on completion of the building
- the risks are likely to be present before the first cycle of planned maintenance for the relevant elements of the building (or before the end of fundamental elements’ lives)
- the potential for regret is commensurate with the risks
- the cost of building the measures is commensurate with the risks
- the risks cannot be adequately addressed by management or behavioural adaptations.

### Reasons to build in adaptive capacity

Designing-in adaptive capacity to the building is worth recommending if:

- the risks are unlikely to be present before the first cycle of planned maintenance for the relevant elements of the building
- the risks are likely to be present before the planned end of the building’s life
- the potential for regret is commensurate with the risks
- the cost of building the planned adaptation strategy is commensurate with the risks
- the risks cannot be adequately addressed by management or behavioural adaptations.

If the risks are very unlikely and the measures to meet them very expensive and/or likely to be regretted then the client is unlikely to invest in a capital measure. A more logical response is to transfer the risk – i.e. insure against it – provided that option is available.

## Business competencies for adaptation

### Options appraisal: assessing the cost-benefits

**Unless they are necessary for compliance or have many important co-benefits, adaptation measures need to be costed and their cost assessed for the benefits that accrue to the client or other stakeholders.**

As climate change risks may only become apparent over time and can pay back in saved future costs, it is helpful to carry out a whole-life costing<sup>85</sup>. The Brighton Housing team tried to spell out what a client needs to hear, although they missed out the issue of timing:

“Climate change will do X to this building, cause Y amount of damage and will mean that the building is less useable, costing you Z. To mitigate against this, this new measure will cost A, but it will reduce occupant expenditure by B, will reduce the maintenance cost by C, and help increase the return on the capital investment by D.”

A whole-life costing can reveal opportunity costs, provided there is an implementation timetable for the adaptation measures (of course, this might be irrelevant to the person paying the capital costs). By following the adaptation plan for the Environmental Sustainability Institute and implementing measures at ‘trigger points’, its team were able to identify cost-efficiencies.

“It was demonstrated that compared to reactively adapting, there would be a lifetime financial saving of 1.5-2.1% (discounted cashflow – the saving would be 4.0-5.8% in undiscounted terms).”

However, not all costs and benefits are easy to quantify.

“A direct cost-benefit analysis of the SUDs scheme is not simple, since the SUDs features are required as part of the planning permission, and provide a range of other services including walking and cycling paths, recreation areas, noise buffers, and general amenity improvement. Assigning costs specifically to its drainage functions is therefore difficult.” (North West Cambridge Development report.)

For clients with a long-term stake in their buildings, the whole-life cost-to-capital ratio for adaptation measures will be low, meaning that their ongoing maintenance and replacement costs are low. Although this was unusual among the D4FC projects, it was the case for the Brighton Housing team, who point out:

“For building owners – such as social housing providers who will maintain an interest in buildings for an extended period – this provides an interesting opportunity.”

For the Betws Washery team, the objective of their cost-benefit analysis was, among other things, to be able to compare measures. They undertook their analysis in three steps:

1. cost comparison between the proposed intervention and its corresponding baseline scenario
2. comparison of the performance of an intervention with its baseline in relation to specific climate change risk. For example, is the proposed drainage intervention better equipped to deal with 2050 climate change rainfall than its baseline?
3. co-benefits analysis. A tool for comparing co-benefits was also required to allow the team to quickly assess whether an intervention option was ‘better’ than another in terms of its costs and benefits. It also allowed cross-comparison of interventions focusing on different climate change impacts. Co-benefits were focused on environmental and ‘in use’ characteristics.

“A whole-life costing can reveal opportunity costs.”

<sup>85</sup> The RIBA Outline Plan of Work was significantly revised in 2013, switching from lettered stages to numbered ones. The new Plan of Work specifically mentions the need for adaptation and emphasises the building in use and the whole life cycle. [www.architecture.com/TheRIBA/AboutUs/Professionalsupport/RIBAOOutlinePlanofWork2013](http://www.architecture.com/TheRIBA/AboutUs/Professionalsupport/RIBAOOutlinePlanofWork2013)

### The phased adaptation plan

**The risk assessment, design options, cost-benefit analysis and the phased implementation of selected measures should come together to make a single phased adaptation plan. The Great Ormond Street Hospital team called this their Climate Change Adaptation Strategy Report.**

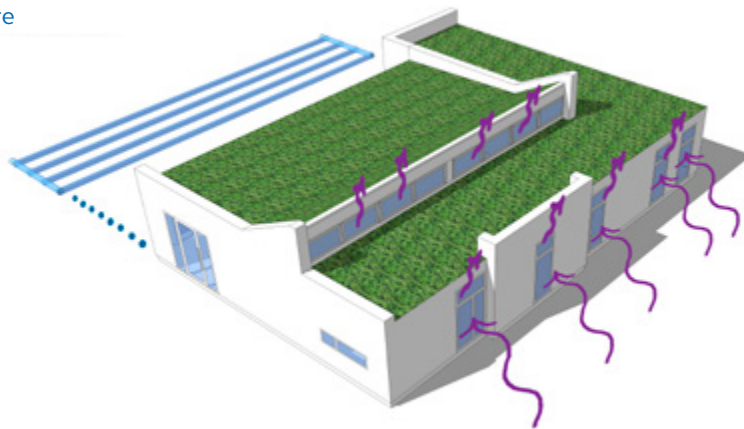
“The strategy will be presented in a digestible manner, with technical analysis, design drawings and specifications issued as an appendix to the report. The report will include four tiers of initiatives:

- recommended initiatives that should be wholly adopted in the design of the new building

- recommended initiatives that should be allowed for in the design of the new building that can allow the flexibility for implementation at a later date
- recommended initiatives that are to be incorporated in the future upgrade works of the building and the likely time horizon and climate change trigger points for incorporation
- initiatives that are not recommended on the basis of the study.”

The St Faith’s School team envisaged more of a live document that they called their Adaptations Toolkit. This detailed the climate change risks and challenges together with recommended adaptation measures and set out likely timelines and triggers for implementation and benefits for the client.

2080 Ground cooling: earth tubes deliver air into each classroom 10 to 12 degrees cooler than ambient air temperature



2030 Green roof upgrade: installed as part of the building’s maintenance schedule

2050 Ventilation adaptation: Implement increased daytime ventilation and night cooling

**D4FC:** Part of St Faith’s School phased adaptation plan

## Business competencies for adaptation

### Project management

#### Project management: plan of work

Most of the D4FC teams commented on how their adaptation work fitted into the RIBA Outline Plan of Work (OPoW), with almost universal agreement that the earlier it starts, the better.

“Adapting the design at Stage C (Stage 2 in the 2013 OPoW) gives the team the widest range of strategies and options. Beyond Stage K (Stage 5) and only very limited changes, if any, can be implemented. However, this does not preclude retrofit measures, so carrying out a whole-life costing during design stage performance assessments helps the building not only to meet necessary construction standards and performance but also to operate it within reasonable projected costs.”

(Welland Primary School report.)

“The D4FC study had the benefit of being introduced into the project at the beginning of RIBA Stage C which, because it is the stage where the design is at its most fluid, offered a perfect environment for developing the adaptation ideas.”

(Betws Colliery Washery report.)

Not only did an early start give the teams enough time to carry out the work, it also helped to give adaptation equal importance compared to other design considerations. It also made it possible to consider the wider financial stakeholder group, potentially bolstering the business case (see Section 2).

“Bringing the climate change adaptation element in at early stages clearly defined the high aspirations for the project everybody was engaged in and set the tone for the working brief and agenda for the team and the rest of the design development that was to follow.”

(Extra Care 4 Exeter report.)

However, in many design-build (and sometimes other) projects, the building designer in charge of design up to Stage 2 is replaced by a different designer for subsequent stages. This is viewed as a risk to the survival of adaptation design intent since the replacement team may not understand the adaptation strategies in full and will likely be focused on saving costs.

“The fundamental problem is still that it separates early design from detailed design and actually, to get this right, you really need to understand the details and the building physics. You actually have to make some fundamental decisions very early on, and this is what falls down in design and build.”

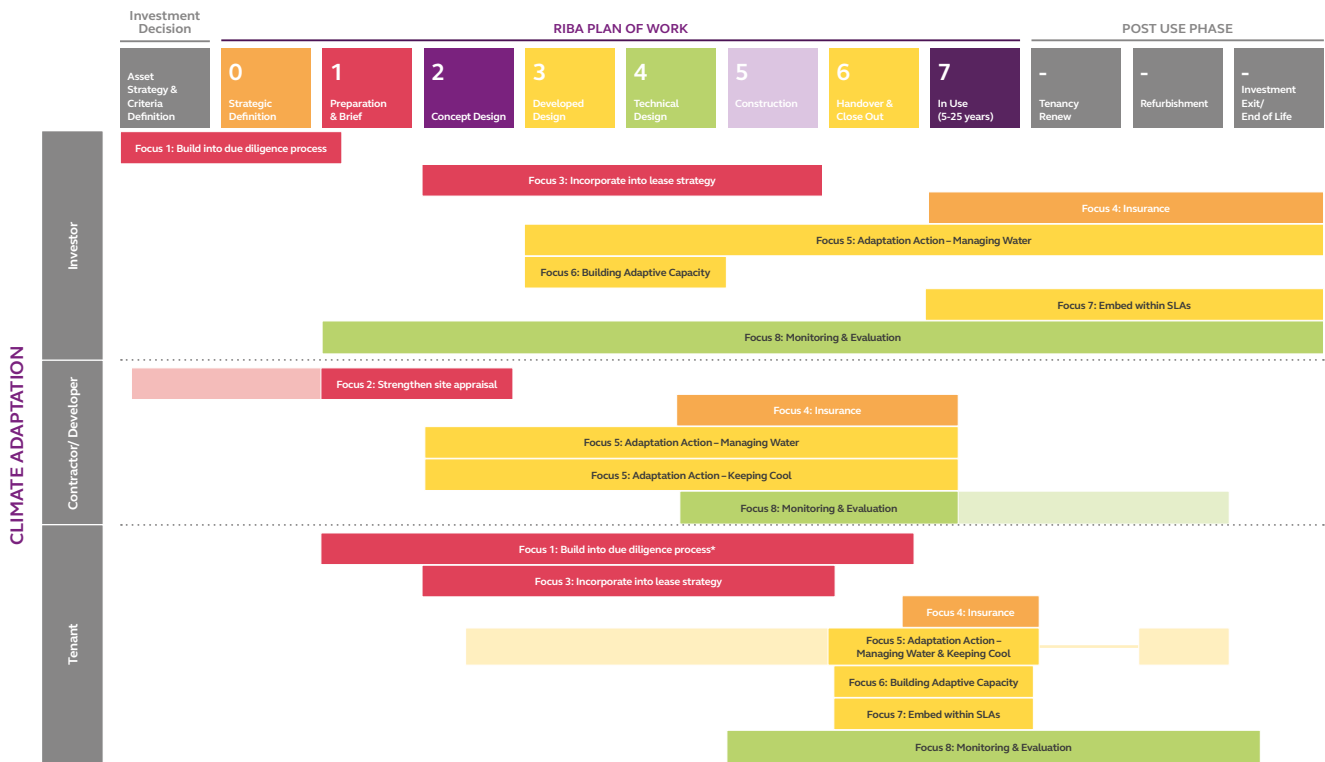
(Expert panel member.)

The Glanford Retail Park team identified the following limitations on adaptation the further into a project it is addressed. Note that it uses the stage numbering from the new 2013 RIBA Outline Plan of Work.

Design Route	Latest Stage of Influence (RIBA Plan of Works)	Approach
<b>1 Design for Prevention</b>	Stage 1/2: Early involvement in the development design, ability to influence the design is high	The design seeks to avoid the impact from occurring
<b>2 Design for Recovery</b>	Stage 3+: Later involvement in the development design, moderate ability to influence the design	The design accepts events may occur and seeks to minimise damage and return to Business as Usual operations as soon as possible
<b>3 Retrofit for Resilience</b>	Stage 7: Solutions that can be retrofitted into an existing/leasehold building	The options seek to minimise risk through prevention and recovery approaches that can be implemented through refurbishment cycles.

**Table 3:** Adaptation routes (Glanford Retail Park project)





**Table 4:** Plan of work table – this table aligns climate adaptation activities with the latest RIBA Plan of Work 2013 milestones to inform the design process. (Deloitte, 2013).

**Project management: management time**

**As the Betws Colliery Washery team discovered, adaptation work consumes management time.**

“The allowance in this team’s project plan was insufficient. It was decided not to sacrifice content. As a result the project has not been profitable for the team leader and the project overran by over six months.”

They recommended restricting the scope to be as narrow as possible to reduce the number of team members necessary to undertake the work, thereby reducing the burden of management and leadership.

The team for the University of Sheffield Engineering Graduate School found that having separate teams for the main design and the adaptation work who worked closely together made it possible to influence the very fast-paced main design effort effectively.

“The knowledge transfer between the two projects was effectively instantaneous and interim results from the adaptation project could be used to influence the main design project without waiting for a finalised set of complete results before communication.”



**D4FC:** Betws Colliery Washery

## Business competencies for adaptation

We asked the expert panel how building designers should pitch climate change adaptation most effectively to clients. Their answers are set out below. Interestingly, there is a concern that designers should be competent to advise, be able to show experience, and should have the capability in-house.

<b>Options appraisal</b>	Life cycle cost analysis
	Demonstrate the financial benefits
	Climate change adaptation could be made more meaningful/valuable to the client if linked into other decisions/priorities/risks – plans/investment/opportunities. For example, low energy lighting strategy with low waste
	Planned upgrade of building with climate change adaptation measures at relatively little or no extra cost. For example, potential for natural ventilation
	Life cycle cost – for future adaptation if not designed for climate change
	Link to future costs/risks
	Identify multiple benefits – short and long term
<b>Communication</b>	Presentation simply of key issues
	Presenting the risks in a simple manner
	Good clear communication. Acting as a consultant, not presenting your client with multiple options and asking them for an opinion
	Not too complex – care with jargon
<b>Assessing the risks</b>	Using appropriate tools to assess risks
	Risk awareness – appropriate!
	Rational and clear identification of both risks and opportunities
<b>Project management</b>	Start early, or after planning. Don't try to force changes during periods of design fixity
<b>Other</b>	Capability in-house
	Demonstrate an understanding of the issues and the measures that can be taken to address them
	Level of competence
	Accept the client's budget and suggest measures that are affordable while being honest about their limits
	Needs to be part of service offerings
	Should be about client engagement, future-proofing and risk-management. Comfortable buildings now and in the future
	Experience – case studies



# 5 Developing the market in the built environment

Climate change science and evidence from the insurance industry indicates that extreme weather events that illustrate future climate change hazards – with good and bad impacts – are on the increase. If construction clients have not already suffered the detrimental consequences of these hazards, it looks as though they are increasingly likely to in the future.

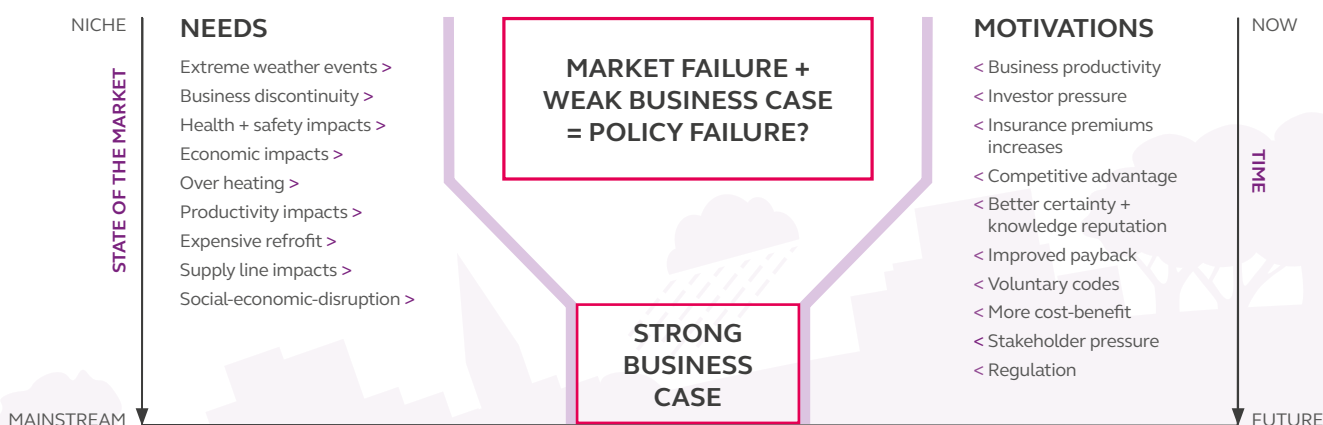
As Section 2 shows, clients are aware of this risk and are beginning to take it seriously, partly because of the self-interest in doing so (if they have an enduring stake in the building) and partly because of pressure from other sources, such as the insurance and investment industries, and other financial stakeholders.

## Current weak market

However, acceptance of the business case for climate change adaptation in the built environment today is still very limited. In the context of other priorities and future uncertainty, clients perceive the risks as too distant to be a current concern. Even where the risks are perceived as relevant, making the business case for capital expenditure to build appropriate adaptation measures is difficult, not just because the internal rate of return is poor but because of a range of other factors too. The D4FC project teams struggled to get the adaptation measures they recommended implemented even though the work to design the measures was at no cost to the client.



“Construction clients are increasingly likely to suffer consequences of climate change.”



**Graph 6:** The Business Case Funnel. The market is currently weak, making it attractive only to small numbers of niche players. Over time, the market will develop by the dual action of necessity and positive motivation. A genuine business case for climate change adaptation will eventually arise, at which stage services to supply it will be mainstream.

### Does adapting buildings matter?

**The key question for the UK as a whole is the extent to which this reluctance to consider adaptation matters both nationally and internationally. Even if we discount the potentially profound social impacts of climate change, adaptation could be a concern purely from the point of view of UK economic growth. In other words, are we concerned that the UK will miss out on a share of the global adaptation market? If so, the only downside of doing nothing is that the UK misses out on boosting its GDP.**

On the other hand, it could be much more serious, with adaptation being a matter of survival of the nation's socio-economic fabric and thus a public good. In this doomsday scenario, the downside risk of not adapting buildings, maladapting or adapting too late has crippling consequences over the long term, with cross-cutting impacts hitting interdependent parts of society to catastrophic extents. And, even if the UK escapes relatively unscathed, it will be impacted by more severe changes occurring elsewhere, in places that we are dependent on for trade – in food, for instance. It is for these kinds of reasons that the United Nations (UN) and the World Economic Forum (WEF) have raised climate change adaptation to near the top of their lists of world risks and challenges in 2015.

### The scope of Government responsibility

The UK Government's National Adaptation Programme<sup>88</sup> (NAP) is based on evidence from their Climate Change Risk Assessment<sup>89</sup> (CCRA). It begins to set the limits of the public interest in adaptation, making it plain that it is seen as mainly an economic issue while acknowledging its wider impacts:

“One of the Coalition Government's top priorities is economic growth and economic resilience. A sound economy is one that innovates, diversifies and is resilient to the challenge of change.

“To ensure that the UK is best placed to remain one of the world's strongest economies, and that our society and environment are resilient, we need to embrace long-term planning and better understand risks, backed up by the best evidence, including horizon-scanning and science.

“Nowhere is this approach more important than in understanding our climate and how it might change. The climate is fundamental to almost all aspects of our lives: it directly affects our economy, ecosystems, food, water, health, homes, infrastructure, trade and leisure.”

The NAP singles out buildings (and infrastructure) for particular attention, saying:

“Climate change may have significant implications for the built environment. Infrastructure assets and buildings are in operation or use for many years, which means that decisions made now about their design and construction will have long-term consequences.”

It highlights these key potential impacts:

- damage to property due to flooding and coastal erosion
- overheating in buildings including homes, schools and hospitals
- increasing impact from the urban heat island effect
- buildings affected by subsidence.

<sup>88</sup> See [www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/209866/pb13942-nap-20130701.pdf](http://www.gov.uk/government/uploads/system/uploads/attachment_data/file/209866/pb13942-nap-20130701.pdf)

<sup>89</sup> See [www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/69487/pb13698-climate-risk-assessment.pdf](http://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69487/pb13698-climate-risk-assessment.pdf)



## Developing the market in the built environment

Obviously, the focus of this report is just about design services for individual buildings in the UK. Nonetheless, given the interconnectedness of economies and cultures, what they say is relevant. If food and water are stressed, supply lines disrupted, strategic infrastructure damaged, large parts of the community in need of emergency help from flooding, to say nothing of the political, fiscal, and economic ramifications of such events, it is possible that the market for building designers in the future will be unrecognisable compared to today. And, surely, ensuring that buildings can adapt to climate change now is part of the overall solution to averting bigger problems later.

The answer is, of course, unknown, but it is likely that preparing buildings now for future climates is about more than just future economic growth but instead concerned with social sustainability and resilience. This is critical to the debate about how the market for building adaptation services should be mainstreamed, and the extent to which the Government should help.

## The risk of relying on adaptive capacity

**Clients who commission adaptation strategies from building designers for their buildings will be presented with a phased adaptation plan. Phased or delayed adaptation is a rational response in the name of allocative efficiency.**

However, it relies on enduring, co-ordinated governance of building operation and upkeep over time, regardless of the economic fortunes of the building owners or users. More importantly, timely deployment of upgrades relies on periodic monitoring of building performance in relation to climate change risks. The Environmental Sustainability Institute team highlighted this as a risk:

*“A sinking fund has not been created to ensure this happens so clearly the risk of this not occurring (for a number of potential reasons) is a barrier to implementation.”*

If the majority of the UK’s climate change adaptation responses in the built environment are such delayed measures, and the UK believes that climate change adaptation is in the public interest, how much faith should we place in building owners and users to deploy phased adaptation as planned? And if that faith is misplaced, what should be the response? Is it possible that the Building Regulations, for example, will need to be amended to have a prospective intent requiring buildings to be monitored and upgraded as and when their performance begins to fail, for example, in relation to overheating?



**D4FC:** PortZED mixed seafront development

### Securing design intent

The expert panel highlighted the risks that original design intent to respond to climate change is lost in both the procurement process and once buildings are in use. There is a specific danger during value engineering, if and when costs are trimmed in the latter stages of procurement and particularly where the original designers are replaced by a new team. Because the new team may not appreciate the rationale for certain measures, especially when the measures are part of a systemic solution. A client on the expert panel said:

“I’ve seen so much dysfunction where there might be five good things, three kept and two got rid of that are so systemically important that the three retained fall over.”

An architect agreed that there is a threat but found that it could be mitigated for overheating risks by clearly communicating the measures in the form of a ‘risk register’ and handing over the energy model to the contractor as part of the employers’ requirements. That way, the contractor can be required to recalculate the energy model to test the impact of any changes proposed.

“It seems to deter the contractor from touching any of those items because the last thing they want to do is recalculate the energy model!”

A senior engineer said that they countered the risks of value engineering by being very precise with their performance requirements, a lesson learnt from taking the trouble to evaluate past performance on other jobs.

An architect from a niche practice recommended engaging the client as a defence tactic:

“You need to get clients in a position where if they’re offered to take out an important measure they will hold onto it because they understand the value.”

Beyond construction, adaptation strategies that depend on certain behaviour from occupants are another important risk. For example, the performance of the building in the Extra Care 4 Exeter project depends on the natural ventilation strategy being understood and properly used, bequeathing the operators a significant management burden. As the Extra Care 4 Exeter report says:

“Ongoing training will be required for care workers as well as maintenance staff. Building manuals and simple user guides will need to be kept fully up to date.”

### The risk of relying on market forces: stranded assets

**The trends in climate change will in time and by themselves create a market for adaptation services from building designers, but will it be soon enough? There is evidence collected in this report to suggest that it will not.**

Clients will likely only commission designs for climate change adaptation reactively as their buildings’ thresholds for coping with, for example, flooding or overheating are breached. The Analytical Annex to the NAP, however, suggests that this kind of reactive response is adequate:

“If adaptation to climate change is in the private interests of individuals and organisations (i.e. cost effective) then in theory it should occur automatically. The value of adaptation will appropriately be reflected in market prices. Individuals and organisations will take advantage of opportunities and will act against the risk of threats through the market.”

The fear, however, is that this reactive response left entirely to market forces or the impact of extreme weather events will only happen when it is too late for affordable remedy, either because its capital cost is too high (i.e. it involves changing the long-lived, hard-to-alter aspects of the building) or the disruption to the activities that take place in the buildings is too severe. The buildings will not be worth adapting, will become less and less useful until, finally, they become prematurely obsolete – the so-called stranded assets. This is especially damaging if other countries are more prepared and exploit the market potential of a poor commercial building stock in the UK.

## Developing the market in the built environment

### Acting earlier leads to a more resilient future

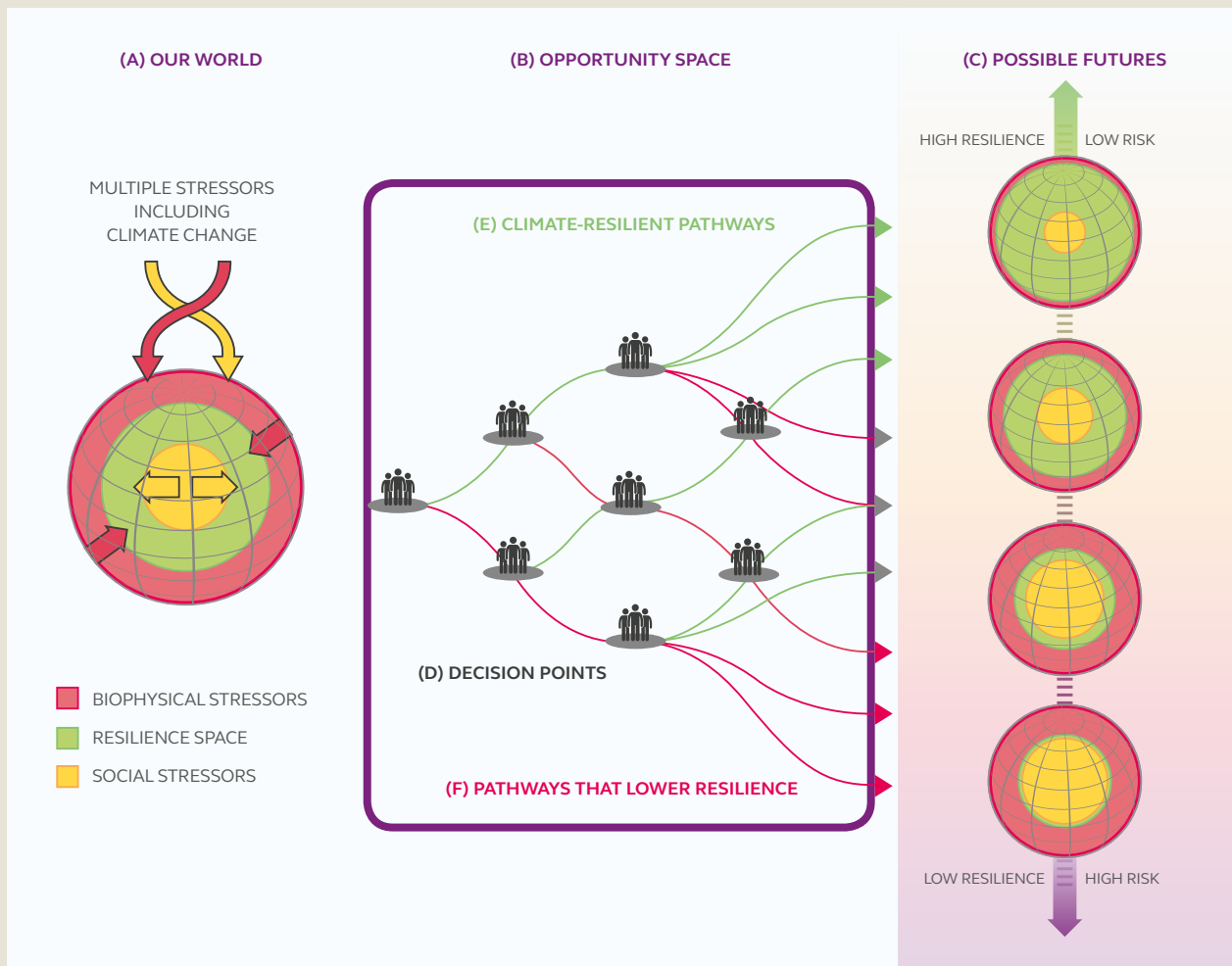
The recent IPCC report Climate Change 2014: Impacts, Adaptation, and Vulnerability is 'highly confident' that adaptation and mitigation choices in the near term will affect the risks arising from climate change throughout the 21st century, implying that action is needed sooner rather than later.

Although global in scope, the IPCC's opportunity model (below) can be applied to the particular case of adaptation in the UK built environment. There is

an opportunity cost in any delay to following green pathways on the model, and the longer one delays, the less resilience is possible.

For individual buildings, this is a private concern. However, if a significant proportion of the country's building stock fails to be adapted in a planned way over time, this will be a collective concern and a matter for government intervention.

### IPCC's opportunity space and climate-resilient pathways diagram



**Figure 16:** Opportunity space and climate-resilient pathways.

Also, in a world where adaptation in every other sector of the economy is also left to market forces, it is possible that this negative effect is reproduced across the country, paving the way to the kinds of doomsday scenarios that concern the UN and the WEF.

Because the future is uncertain and the impact of no or sub-optimal adaptation is potentially huge, the precautionary principle should apply. Rather than delaying adaptation until there is a market for it, it is more resource-efficient – and safer – for the UK’s building stock, and by extension the UK’s economy, to be built with the capacity to adapt designed in now. (And if the risks are high enough, the benefits outweigh the costs, and the potential for regret is limited, it is better to build it with adaptations already in place.) The question is how to stimulate the market to consider adaptation in the built environment and to proactively commission building designers to help them.

### Reasons for Government intervention

**One of the factors that contributes to the slow uptake of some adaptation measures is that construction clients – private entities – are reluctant to pay for those that principally benefit others. Talking about the possibility of Government intervention, a member of the expert panel observed that:**

“If you want to adapt to climate change, quite often you end up having an externality which is a positive gain for the community, for sustainability in general. But from a financial perspective, from a pure developer or property owner perspective, it’s just a cost. Unless Government promotes those things, they won’t happen.”

As the text box on the following page shows, delegates at the Innovate UK D4FC legacy conference offered a variety of reasons for the need for intervention. The UK Government however thinks that it should intervene only where it identifies barriers, or ‘failures’, or where there is a public good. The Analytical Annex recognises that barriers to adaptation do exist:

“These barriers prevent a socially efficient level of adaptation from occurring. It could result in too little or too much adaptation taking place, leading to a misallocation of resources. Government has a role to play to ensure adaptation actions are economically efficient. It also has responsibility to ensure public goods, such as national infrastructure (for example, the road network) and non-market goods (for example, environmental amenities) are resilient to climate change.”

Although of course there are many other justifications for government intervention, market (or other) failures are acknowledged in the Analytical Annex to the NAP, which gives hope to the possibility of Government intervention.

Government intervention can take many forms, from commissioning, supporting and promoting research through to legislating new mandatory rules and regulations where there is a policy failure.





## Developing the market in the built environment

### Extreme weather events as triggers for policy change

Events that catastrophically affect large numbers of people and cost billions can trigger policy change, which in turn require public and private clients to respond.

#### The storm surge of 1953

The floods of 1953, which killed more than 300 people in Eastern England and cost a total of about £1.2bn in today's money<sup>90</sup>, led eventually to the construction of the Thames Barrier.

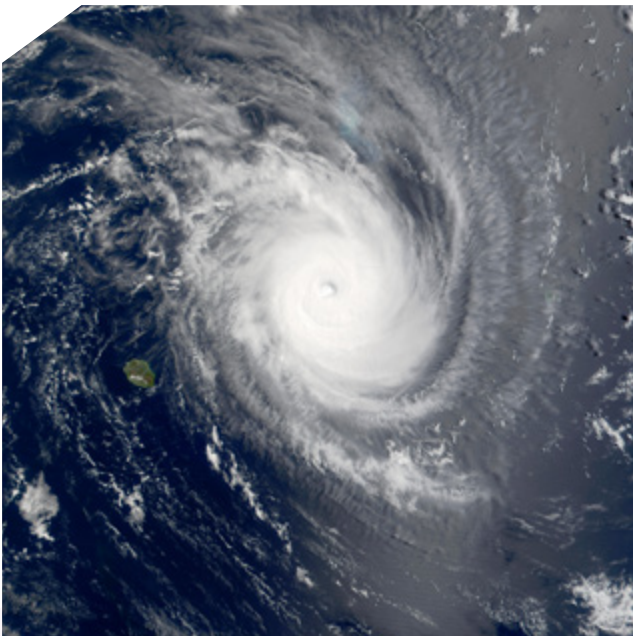
Across the sea in the Netherlands, where more than 1,500 died, the Dutch government seized on the opportunity to invest huge amounts of public funds in coastal flood defences in works called the Delta Project. This was backed up by legislation called the Delta Law that required the government to keep risks of catastrophic flooding within set limits and, importantly, to upgrade defences should the risks demand it. Indeed, a recent risk assessment that took account of climate change obliged the government to carry out more work, due to complete in the next few years.

#### Hurricane Sandy

More recently, the deadly Hurricane Sandy affected many countries including the USA, where during October 2012 it wreaked monumental economic damage amounting to \$65bn. In New York, its storm surge flooded streets, tunnels and subway lines and cut power in and around the city.

It has resulted in a comprehensive review of the building codes for New York City including practical guidance and new flood maps. It also embraces working with nature, which was shown to work through the PlaNYC (the sustainability and resiliency blueprint for New York City) initiative's \$2.4bn green infrastructure plan that uses natural methods of capturing rainwater before it can flood communities and overwhelm the sewage system. It requires major developments in vulnerable areas to undertake a climate risk assessment.

The policy impact of Sandy also spawned the 'Risky Business' initiative<sup>91</sup> to assess the national exposure to risk, backed by big-hitters in politics and finance.



### Policy failure

**Many of the final reports of the D4FC programme describe inadequate regulations and published standards as significant contributors to the apparent market failure.**

In part this was to do with having no agreed way to approach an issue but it also reflected on the perceived importance of adaptation in comparison to other design issues that are regulated. Designer, client, local authority and academic delegates at the February 2014 'Building a Resilient Future' conference certainly agreed that the Government needs to intervene (see text box on following page).

<sup>90</sup> For the story, see the Met office website: [www.metoffice.gov.uk/news/in-depth/1953-east-coast-flood](http://www.metoffice.gov.uk/news/in-depth/1953-east-coast-flood)

<sup>91</sup> The Risky Business initiative undertook an independent climate change risk assessment for the USA to engage with economic sectors most at risk. Michael Bloomberg's co-founders are Hank Paulson, former US Secretary of the Treasury, and Tom Steyer, retired founder of Farallon Capital.



### Conference opinions: should Government update standards and regulations?

At a D4FC legacy conference, respondents overwhelmingly agreed that government has a duty to co-ordinate and support the updating of building design regulations and standards to include allowances for future climate change. A designer said:

“A lot of action is for the common good and so government action is needed in some places.”

Another suggested an appropriate regulatory vehicle:

“Need a climate change adaptation equivalent to the CDM Regulations (Health & Safety) to place duties on each of the participants in construction projects: clients, designers and contractors.”

A local government employee suggested:

“A ‘climate resilience’ statement being a requirement of a submission for planning permission.”

However, several respondents commented on the need for political will and long-term planning – anathema to governments focused on short-term electoral cycles and committed to trying to cut environmental standards seen as red tape. One respondent said:

“There is currently a total failure on their part to do this, with the de-regulation movement failing to understand there are times when leadership is required.”

Others warn of vested interests working against those in favour of regulation, while others warn of enforcement impotence:

“The delays to the latest Part L show the extent to which the government can be influenced by lobbying groups.”

“It’s important that all issues that can reasonably be controlled through policy or regulations are. But enforcement is needed.”

Finally, several voices articulated bigger picture concerns:

“This issue is more than building regulations. It needs a strategic cross-departmental approach to settlement scale infrastructure.”

“We need much greater cross-institutional efforts to demand this. Enforcement is ridiculously loose across the whole range of environmental regulations.”

The D4FC teams’ most worrying concern, however, was that current design practice, especially that mandated by the Building Regulations, uses historic measured data which are already out of date. In other words, current standards and regulations are not fit for today’s climate, let alone what may come in the future. As the team working on the PortZED project concluded:

“A climate change adaptation scoring should be immediately introduced into Code 6 to steer the industry away from adopting construction techniques that will not maintain the required performance standards throughout the worst anticipated future climate scenarios. There seems little point in worrying about whether low, medium or high climate change scenarios should be adopted – as the worst case scenario should be used to future-proof a massive national investment in new building stock.” (PortZED final report)

“Standards and regulations are not fit for today’s climate, let alone the future.”

## Developing the market in the built environment

### Forcing the market and building consensus

Government can respond to the need to boost the market and address the policy failure in several ways. The steps include:

- exploiting the research already concluded, in particular the extraordinarily rich information contained in the D4FC programme outputs, especially the final reports
- more research (with grant funding), proper dissemination, and demonstration projects
- concerted action from professional organisations such as CIBSE and RIBA
- lobbying from special interest groups
- improvements in tools; exemplars that show what is possible
- voluntary standards, codes and schemes
- local authority planning requirements
- British Standards
- Building Regulations.



### How to build the market

The Environmental Sustainability Institute team concluded that to establish a market there should be mandatory standards, quasi-voluntary standards and client-led drivers. They also identified the need for the following.

**Improved knowledge and data sources:** to combat uncertainty, improve reliability and thus reduce risks.

**Standardisation of approach:** to make it possible to set performance standards, compare service offers, and price the cost of service delivery. Mostly, though, this would streamline the process, making it cheaper and thus more likely to be taken up by clients. They recommend producing a publicly available specification based on evidence in the D4FC projects.

**Approaches to handle future innovation:** to ensure that technological advances during the life of buildings can be identified and accurately exploited in phased adaptation. They suggest a ‘future thinking resource bank’ outlining potential technologies, technical performance, and projected costs.

**Automated means of optimisation of bulk parameters:** to overcome the complexity in identifying the most effective adaptation strategies. They highlight the following variables:

- climate conditions
- potential interventions
- performance criteria
- cost data
- approach to risk
- user requirements
- wider political and societal change.

### Research and demonstration projects

**The D4FC programme has made an enormous contribution to the state of contemporary knowledge. There is a huge amount of other research under way, notably under the aegis of the Adaptation and Resilience in the Context of Change Network<sup>92</sup> (ARCC).**

The expert panel agreed that there is a need for demonstration projects. This is a difficult concept in practice because climate change is a moving target. However, projects that monitor the performance of adaptation strategies to see how they perform under current weather conditions and establish how this can be extrapolated to indicate future performance could prove useful. According to a small architect's practice:

"Clients want an exemplar, a demonstration project measured and monitored to show how this adaptability performs better. It is very difficult to talk about these issues without being able to show them."

Another architect working for a local authority is trying to raise funding for a demonstration project:

"The idea is to see what climate change adaptation we can do now but also for the future – monitoring before and after. Ideally we'd like to develop a shopping list from that so that if you've got x amount of money, these are the things you can do in old buildings."

Two ARCC projects, Suburban Neighbourhood Adaptation for a Changing Climate<sup>93</sup> and Design and Delivery of Robust Hospital Environments in a Changing Climate<sup>94</sup> have produced useful adaptation case studies that reflect the practicalities (budget, client and occupant preferences) of implementation.

### Professional institutions and special interest groups

**As guardians of professional values and representatives of their respective memberships, the institutions – CIBSE, RIBA, RICS, and so on – are well placed to promote the need for adaptation. In doing so they can advance the science and help to create a new market for their members. An expert panel member agrees that these bodies should be leading:**

"The professional bodies have a role here. We're not putting enough pressure on them."

A designer responding to the conference questionnaire<sup>95</sup> said:

"It's in the code of conduct of professional institutions to put the client's needs first but the professional institutions don't make clear what this means in practice for climate change adaptation."

Needless to say, much is already being done, with CIBSE in particular at the centre of much of the technical thinking for some aspects of adapting buildings to future climate change. It has just published a series of case studies, for instance, based on the D4FC programme – TM55 Design for Future Climate: Case Studies<sup>96</sup>.

Special interest groups are also a key driver for change, unifying people from different disciplines and walks of life together in one forum. Existing organisations such as the Modern Built Environment Knowledge Transfer Network<sup>97</sup> and the Green Building Council<sup>98</sup> are already pressing for change, while new ones will appear. For example, at the time of writing the BRE announced its intention to create a 'centre for resilience' to develop 'standards for design, planning and products, and skills-related programmes', among other things<sup>99</sup>.

**"There is a need for demonstration projects to show how adaptability performs better."**

<sup>92</sup> See [www.arcc-network.org.uk](http://www.arcc-network.org.uk)

<sup>93</sup> See [www.arcc-network.org.uk/project-summaries/snacc](http://www.arcc-network.org.uk/project-summaries/snacc)

<sup>94</sup> See [www.arcc-network.org.uk/project-summaries/dederhecc](http://www.arcc-network.org.uk/project-summaries/dederhecc)

<sup>95</sup> See <https://connect.innovateuk.org/web/design-for-future-climate/documents>

<sup>96</sup> See [www.cibse.org/knowledge/cibse-tm/tm55-design-for-future-climate-case-studies](http://www.cibse.org/knowledge/cibse-tm/tm55-design-for-future-climate-case-studies)

<sup>97</sup> See <https://connect.innovateuk.org/web/design-for-future-climate/overview>

<sup>98</sup> See [www.ukgbc.org](http://www.ukgbc.org)

<sup>99</sup> See [www.bre.co.uk/page.jsp?id=3326](http://www.bre.co.uk/page.jsp?id=3326)

## Developing the market in the built environment

### Improvements in computational tools

There are many calls from the D4FC project teams for improving the tools that help with modelling and risk assessment. For example, the North West Cambridge Development team expressed the view that a number of resources, techniques and models are in their infancy and subject to error.

‘Until there is some form of standardisation or guidance, a large number of alternative analysis methods will remain in use, potentially causing inconsistency.’

### Voluntary standards, codes and schemes

**Voluntary standards such as BREEAM and PassivHaus, especially if based on robust evidence, can help to pave the way to best practice, becoming forces for the improvement of the built environment.**

As recognised quality marks, they serve a useful purpose to clients who need a shorthand way to communicate their buildings’ credentials either in furtherance of their corporate social responsibility or to differentiate their product for a higher yield. However, at present neither of these addresses climate change sufficiently to enable development of a phased adaptation strategy.

The expert panel felt that BREEAM, which was amended in 2014 to consider climate change adaptation<sup>100</sup>, was a useful starting point. However, as yet there is no way to compare the relative future climate readiness of a building, important if any such standard is to be of use to clients.

“We don’t look at how well a building is adapted in comparison to another. You can do that for energy, carbon and other things. There’s an index missing somewhere.”

This is undoubtedly a complex task but, if achievable, could be an important milestone on the road to mainstreaming.

### The lessons of the Code for Sustainable Homes

During the writing of this report the Code for Sustainable Homes was abandoned under the UK Government’s Housing Design Review<sup>101</sup>:

“Many of the requirements of the Code for Sustainable Homes will be consolidated into Building Regulations, which would require substantial changes to the content of the current code, as well as a reconsideration of its role. In the light of this, the Government thinks that the current code will need to be wound down to coincide with the changes incorporating the new standards coming into force.”

There is considerable concern in the sustainable design community about what will happen to the tenets of the scheme that are not being consolidated into the Building Regulations. Nonetheless, this transition from voluntary scheme to legal requirement demonstrates a possible route for mainstreaming innovative practice. It is particularly interesting in view of the Coalition Government’s campaign to reduce red tape and their consequent aversion to legislating new regulations.

Note that the Housing Design Review was triggered by the desire to tidy up a legacy of regulations and guidance developed piecemeal over time and without any guiding compass. If there is a regulatory approach to adaptation, it should not repeat this mistake.

<sup>100</sup> See Appendix 2 and [www.breeam.org](http://www.breeam.org)

<sup>101</sup> Completed in March 2014, the Housing Design Review was ‘a radical reform of the framework of building regulations, guidance, local codes and standards which aimed to reduce bureaucracy and costs on house builders - supporting growth whilst delivering quality, sustainability, safety and accessibility.’ [https://www.gov.uk/government/uploads/system/uploads/attachment\\_data/file/230250/1-Housing\\_Standards\\_Review\\_-\\_Consultation\\_Document.pdf](https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/230250/1-Housing_Standards_Review_-_Consultation_Document.pdf)

### British Standards and quasi-mandatory codes of practice

**British standards and other quasi-mandatory codes are the lifeblood of commercial practice, and an obvious route for influencing building design practice to grow the market for adaptation services. As the North West Cambridge Development final report says:**

“Without this, there is a risk that designs which include adaptation features may be seen as non-compliant with codes and guides, or simply not addressed.”

A senior engineer member of the expert panel said:

“People really won’t get the same answers until then. The D4FC studies recognised that.”

The British Standards Institution has already started down this road in conjunction with Climate Ready<sup>102</sup> by producing a practical guide to help business continuity professionals understand and manage severe weather risks as part of their existing business continuity management system. The guide sets out a series of tasks in line with ISO 22301, enabling organisations to improve their ability to deal with weather-related disruptions<sup>103</sup>.

### Planning

**The straw poll of the members of our expert panel found that planning was marginally more favoured as a way to enforce adaptation than, for example, the Building Regulations (see text box next page).**

“Planning is helpful because it sets where the building’s located, the elevations, the section. Without that fundamental understanding of the building form and how it sits on its site, climate change adaptation isn’t going to be very effective. If that’s wrong you’re left fiddling about with the design which is unsatisfactory and much more expensive. If you do it right at the beginning there’s virtually no extra cost.”

Local authorities have certain powers to tailor overarching planning requirements to local needs as well as to clarify existing rules in the National Planning Policy Framework (NPPF – see Appendix 2). An architect member of the expert panel who works for a local authority is doing something similar as a direct result of their experience of their D4FC project.

“We’ve taken the findings from our project and taken it to our cabinet and they’ve approved that to be an integral part of the design codes we’re developing. We’re now exploring what teeth it can have. Is it just a recommendation or is there some way to enshrine and protect that within planning policy?”

On the city-wide scale, the Mayor of London is obligated to produce a spatial development strategy<sup>104</sup> which is also legally part of the development plan that has to be taken into account when planning decisions are made in any part of London. Known as the London Plan, it was updated in 2011 and is another example of how climate change adaptation measures have crept into the policy framework for the built environment. Despite this, climate change adaptation is only mentioned there in relation to green and transport infrastructures. In his foreword, the Mayor makes it clear that climate change is one of the key drivers for the new edition:

“This plan also supports changes in how we live and do business taking account of a changing climate – think of how living in and using a city will change as the sort of summer temperatures experienced today as a heatwave become the norm.”

It is backed up by a climate change adaptation strategy for London<sup>105</sup>, with the focus on flooding, drought and overheating, with ‘cross-cutting issues’ of health, environment, economy and infrastructure.

<sup>102</sup> Climate Ready is the UK Government’s initiative to help businesses, communities and the environment adapt to a changing climate. The Environment Agency provides this support service: <http://webarchive.nationalarchives.gov.uk/20140328084622/http://www.environment-agency.gov.uk/research/137557.aspx>

<sup>103</sup> See ‘Adapting to Climate Change Using Your Business Continuity Management System’ - [www.bsigroup.co.uk/en-GB/forms/Adapting-to-Climate-Change-using-your-Business-Continuity-Management-System](http://www.bsigroup.co.uk/en-GB/forms/Adapting-to-Climate-Change-using-your-Business-Continuity-Management-System)

<sup>104</sup> GLA. (2011). *The London Plan: Spatial Development Strategy for Greater London*. London: Greater London Authority. [www.persona.uk.com/nle/B-Core\\_docs/E/NLE\\_E12.pdf](http://www.persona.uk.com/nle/B-Core_docs/E/NLE_E12.pdf)

<sup>105</sup> GLA. (2011). *Managing Risks and Increasing Resilience: The Mayor’s Climate Change Adaptation Strategy*. London: Greater London Authority. [www.london.gov.uk/sites/default/files/Adaptation-oct11-exec-sum.pdf](http://www.london.gov.uk/sites/default/files/Adaptation-oct11-exec-sum.pdf)



### Would Government intervention be fair?

We asked our expert panel members<sup>106</sup> whether it would be fair for the British Government to impose mandatory obligations (through planning, Building Regulations or other legislation) on construction clients to prepare for future climate change?

There was very little comment actively against the idea, although one respondent did not think it would be fair on the grounds of it being 'yet more legislation and cost to the client'. The comments in favour were articulated in terms of concern for public value, as set out below:

It would be fair:

- to end-users to ensure buildings are safe – robust and long-lasting
- for aspects that impact on others (for example, run-off)
- to have specific legislation to mitigate risk at society level
- for other aspects, like overheating, very difficult to do until a standard approach has been identified, for example, applying current CIBSE overheating guidelines would disincentivise buildings that would be OK with adaptive thermal comfort
- in line with changes to next Building Regulations
- because the effects of climate change would be severe and so it is quite reasonable to expect designers to be 'encouraged' (and clients persuaded) to prepare
  - to engage and consult
  - because it extends to current extreme weather events and future climate change
  - but would have to be applied at all stages of construction
  - but would need to be proportionate and reasonable
  - If related to economic cycles... 2016? 2019? – part of revision to Building Regulations
  - as part of an environmental impact assessment – EU directive/revisions to include climate change adaptation
  - as part of a code of construction practice – inclement weather/extreme weather events
  - as part of BREEAM requirements – stronger links to extreme weather events/climate change adaptation
  - to coincide with changes to the Building Regulations – in 2016?
  - Because the building will last into future and so needs to be resilient/reduce future climate change
  - where the benefits are for public good. To respond to market failure – for example, housing. Slow process so aim for 2019 regulations
  - if within the next three years. This would at least provide a standard benchmark against which all future developments could be assessed.

<sup>106</sup> <https://connect.innovateuk.org/web/design-for-future-climate/documents>

### Building Regulations

**The D4FC project teams noted that the Building Regulations do not take account of climate changes already under way let alone future change. The Environmental Sustainability Institute team said:**

“There are currently no specific regulations to ensure that buildings are adapted to potential future climate risks. Therefore, adapting to climate change does not carry the same weight as other issues (for example, carbon compliance, keeping within budgets etc.) and so is a lower priority.”

They made an argument for the regulations to be amended:

“If it can be shown that there are measures that building projects should be incorporating now in order to make the nation’s building stock more resilient come the end of the century, then regulations and building codes provide a more certain means of achieving this.”

If there is cause to amend the Building Regulations, which the expert panel felt that there was, then, within reason, it should happen as soon as possible. An expert panel member with experience of Government consultations in this arena said:

“Realistically, the earliest is 2019, assuming the 2016 cycle and 2019 Building Regulation updates happen. I don’t think the evidence is robust enough yet to get anything earlier.”

There may be other approaches, such as the suggestion from the conference to treat adaptation rather as health and safety is legislated for through the CDM Regulations. This could be a ‘passport’ that highlights the adaptation strategy, the measures included and the phased adaptation plan.



## Developing the market in the built environment

### Effects of mainstreaming

#### The effect on fees

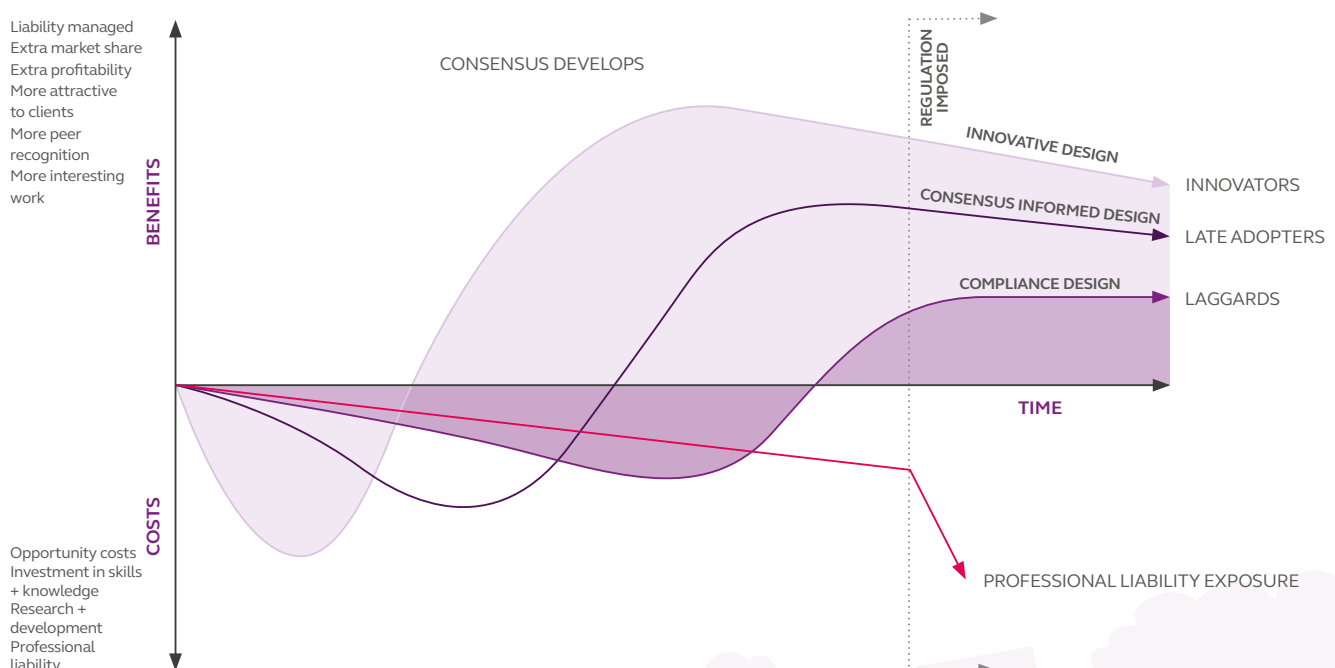
**Section 4 showed that carrying out adaptation work at the moment can be extremely time-consuming and thus expensive for both clients and design teams, regardless of whether it is charged for.**

Although there is considerable potential to streamline processes – with consensus, standardisation and enhanced modelling techniques – accommodating climate change adaptation in the professional offer is still likely to require more time and thus be more expensive than not doing so. This is because it requires the building design to be analysed against current regulatory standards, which

uses historic data, in addition to any work using future data. Even when the market matures and practice is fully streamlined, the professional offer will remain more expensive for clients.

This is a policy failure - a disincentive for clients and a barrier to developing the market. Only when the regulations (and supporting standards) change will the professional fee be the same as not designing for future climate, adding to the argument in favour of upgrading the Building Regulations.

Note, however, that since climate change is a moving target, there will still be a market for an enhanced service. This is because some clients will want to go further than the minimum regulation, for example, to protect their long-term interests.



**Figure 17:** Notional cost-benefit curves for innovators, late adopters and late-comers to the market (laggards). Innovators invest sooner, gambling on net benefits over time as consensus builds and before regulations level the market. Late adopters take a lesser bet, following the growing consensus, standing to reap fewer rewards. Laggards merely comply, gearing up in advance of regulation. They stand to merely break even but leave themselves open to professional liability for longer.

### The effect on client confidence

**Standards and regulation (as much as professional bodies of knowledge) build a picture of what it is reasonable to expect from building designers.**

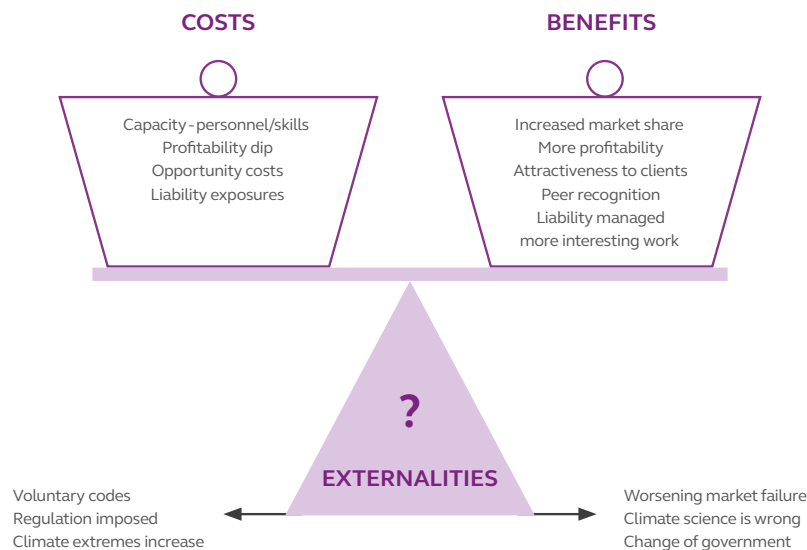
It establishes a professional standard that helps to define the boundaries of professional negligence, improving the business case by building confidence that there is legal redress in the event that things go wrong.

### Commercial advantages of innovation

**Section 3 showed that building designers participating in the market now are innovators. Even when this is an ethical choice, they are taking a gamble on ‘gearing up’ based on the expectation of a bigger market in the future (see Figure 18 below).**

In doing so, they may be stealing a march on their competitors and putting themselves at the front of the queue when it comes to securing adaptation work if the market takes off. It is even possible that, as demand grows in advance of proper mainstreaming, they will be able to sell their services at a premium, increasing the profitability of their businesses, although of course this is speculative.

As time passes and the market develops, more and more firms will follow the innovators. However, those who have entered the market sooner have an important competitive advantage over the later arrivals. They will either continue to be able to offer the service at a premium or to win a greater share of the wider construction market (see Figure 17 on facing page).



**Figure 18:** The uncertain cost-benefit balance. Building designers have to balance the cost of gearing up against future positive rewards. The calculation is swayed by uncontrollable and uncertain externalities that shift the fulcrum either in favour of investment or against it – a disincentive to taking the leap.

## Developing the market in the built environment

### Changes to practice with mainstreaming

#### Collaboration and sharing

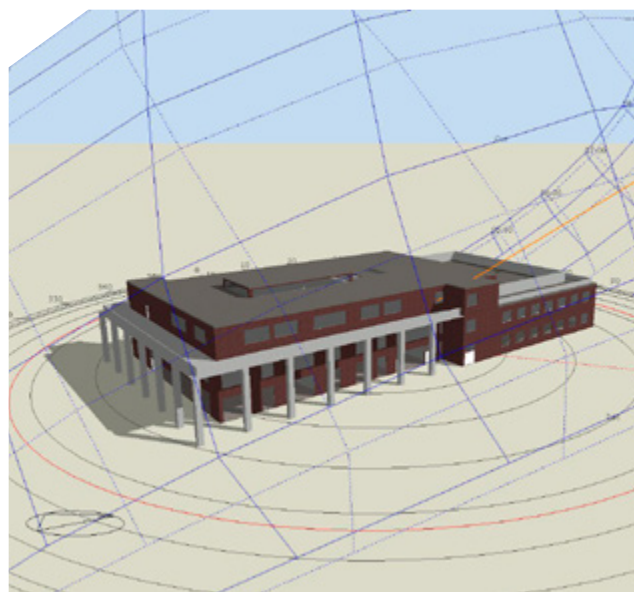
The multi-disciplinary nature of adaptation work requires close collaboration and the appreciation of other areas of professional expertise.

#### The promise of building information modelling

As a collaborative way of working that allows more efficient methods of designing, creating and maintaining assets, building information modelling (BIM) may make a game-changing difference to the delivery of assets that have long-term resilience to climate change.

BIM holds out the promise of being able to acquire and manage vast amounts of data that could include weather and component data, usage projections, future developments and much more. All of this data could enable collaborative working on highly complex models to allow simulations to be run and optimise the design solution at both a building, street or neighbourhood scale. Future developments in this technology could even enable the establishment of city-wide models covering a host of factors including weather and natural environment effects on the built environment.

In 2011, the UK government partnered with the construction industry with the aim of delivering all centrally funded public procurement using Level 2 BIM by 2016<sup>107</sup>.



D4FC: St Paul's project.

#### Briefing

**It is critical to get the brief right from the start, including agreeing assumptions in the context of an almost infinite range of possible design criteria.**

As the market matures, new advice for developing briefs with clients that emphasise the needs of all financial stakeholders will help to streamline practice. An architect expert panel member said that the profession cannot supply an adaptation service:

“Without life cycle costs, weather files, or understanding who the user will be. We can't keep on working almost blind.”

<sup>107</sup> More information on the task group and BIM levels can be found at [www.bimtaskgroup.org](http://www.bimtaskgroup.org)



### Improving practice generally

**The methodological rigour required to implement the D4FC projects demonstrated the ability of design teams to extend their expertise to tackle unfamiliar issues and thus highlighted the extent to which this exceeded standard design practice.**

The requirement to consider climate change impacts such as overheating made designers look at their current design approaches and the implications of very rapid changes in construction practice with fresh eyes. The exercise revealed deficiencies that appeared obvious in hindsight.



If this is so, it has very far-reaching implications not just for climate change adaptation but for the built environment professions as a whole. Such a shortfall also impacts on current standards and regulations, adding to the debate about whether the seriousness of the risks means that regulations should be revised.

As with all threats, this realisation can also be an opportunity to adjust practice not just to improve technical outcomes but to overhaul building designers' relationships with clients. As one architect said:

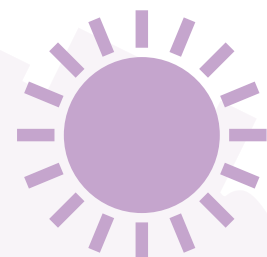
“Architects and engineers have to understand how the building they deliver supports – as opposed to undermines – their client’s ability to achieve their strategic business objectives. That’s the good bit for me about climate change adaptation – it raises this issue in a way that some others don’t.”

There is now considerable momentum behind efforts to stimulate the market for climate change adaptation in the built environment, a world-beating advantage that should not be squandered. The St Faith’s School team pointed out:

“The database being developed by Innovate UK of the ‘Design for Future Climate’ projects will add to the overall knowledge of the subject. It is important that the individual project conclusions are gathered together to develop a summary of ‘working tools’ and a point of reference providing valuable advice and best practice for all designers, clients and building providers in the area of climate change.”

It is hoped that this report, its insights and recommendations will spur further development in this important endeavour.

“We can’t keep on working almost blind.”



# Appendix 1

## Terminology

**The language of climate change adaptation has yet to be standardised in building design practice. This can lead to confusion and misunderstanding, particularly where the words have alternative meanings. In this report, the important terms are defined as follows:**

**Adaptation:** The process of making changes over time to the design, construction, operation and use of buildings to moderate potential damages, cope with negative impacts, and exploit the beneficial opportunities from climate-change hazards. Adaptation considers not just their effect on the fabric of buildings, but on their contents, operations, and the people who occupy them too. It is about how to make buildings more resilient in the face of identifiable risks.

**Adaptation measure:** A design, management or behavioural intervention that is part of the overall adaptation strategy.

**Adaptive capacity:** The ability or potential of a building, its operation and occupants to adjust to future climate change hazards while retaining the same basic structure and ways of functioning. It is the term used to describe a building's resilience to changes in climate.

**Consequence:** An impact such as economic, social or environmental damage/improvement that may result from a climate change hazard. May be expressed quantitatively (for example monetary value), by category (for example High, Medium, Low), or descriptively.

**Extreme weather event:** A weather phenomenon at the extremes of the historical record, especially severe or unseasonal weather, and characterised by being difficult to predict. Note that as the climate changes, events that are extreme by today's standards may cease to be classified as such in the future.

**Hazard:** A climate-change-related phenomenon with the potential to result in harm. A hazard does not necessarily lead to harm<sup>108</sup>.

**Maladaptation:** Adaptation, or an adaptation measure, that proves to be more harmful than helpful by having unintended consequences.

**Options appraisal:** The formal process used by building design teams to allow construction clients to consider, validate and prioritise proposed adaptation measures. This is not just about the comparative effectiveness of measures; it has a strong focus on cost-benefit analysis too. It should extend beyond economic considerations to include other forms of benefit, for example social (health and well-being) and environmental (biodiversity).

**Resilience:** The ability or potential of a building and its operation to adjust to future conditions (including climate change and extreme weather events) 'while retaining the same basic structure and ways of functioning'<sup>109</sup>. Adaptive capacity is a subset of resilience.

**Risk:** Probability of a hazard multiplied by its consequence. (See diagram on p. 23).

**Risk analysis:** The formal methodology used by building design teams to identify and quantify the vulnerability to hazards of buildings, their contents and operations, and the people who occupy them. It is a step in designing for adaptation.

**Vulnerability:** The degree to which a building, its operations or occupants are susceptible to and unable to cope with climate change hazards, including climate variability and extremes.

*"Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a building is exposed, its sensitivity, and its adaptive capacity<sup>110</sup>."*

It is analysed during the risk assessment and minimised by several responses, including adaptation or adaptive capacity.

<sup>108</sup> HR Wallingford. (2011). *Language of Risk - project definitions; and Management Methodologies*. London: Greater London Authority.

<sup>109</sup> Nicola Ranger, A. M. (2010). *Policy brief: Adaptation in the UK: a decision-making process*. The Grantham Research Institute on Climate Change and the Environment and The Centre for Climate Change Economics and Policy.

<sup>110</sup> Ibid.

# Appendix 2

## Current legislative background

**There is broad-sweep legislation underpinning the need to address climate change, most prominently in the Climate Change Act (2008). However, the provisions do not directly regulate the built environment or building designers.**

In fact, there is currently very little legislated compulsion in the UK to design for adaptation in new or existing buildings, and commonly used standards rarely include specific allowances for climate change. Inevitably, this lack is blamed for hindering the take-up of adaptation in contemporary building design practice, a theme that crops up often in the discussion about climate change adaptation in the D4FC projects. This is considered in more detail in Section 5.

### The National Planning Policy Framework

**What little legislation exists is implemented through the planning system. The regulation concentrates on flooding, which is the only risk with detailed guidance accompanying the National Planning Policy Framework (NPPF)<sup>111</sup>, called, appropriately enough, *Technical Guidance to the NPPF (largely replacing the old Planning Policy Statement 25)*.**

The NPPF emphasises that responding to climate change is central to the economic, social and environmental dimensions of sustainable development. (Scotland and Wales have different planning frameworks.)

Local planning authorities have a statutory duty under Section 19 (1A) of the Planning and Compulsory Purchase Act (2004)<sup>112</sup> to create Local Plans 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’.

They must pay particular attention to integrating adaptation and mitigation approaches and looking for ‘win-win’ solutions that will support sustainable development. For example, the Technical Guidance suggests this can be done:

- by maximising summer cooling through natural ventilation in buildings and avoiding solar gain
- through district heating networks that include tri-generation (combined cooling, heat and power)
- through the provision of multi-functional green infrastructure, which can reduce urban heat islands, manage flooding and help species adapt to climate change – and contribute to a pleasant environment that encourages people to walk and cycle.

It also warns of the risk of maladaptation, such as artificial cooling a building in an urban context without heat recovery, which can exacerbate the urban heat island phenomenon.

Basic requirements for resilience in the current climate are included in the Building Regulations (Scotland and Northern Ireland have different building regulations, with Wales to follow soon). Design standards, tolerances and thresholds also related to today’s climate are set out in British Standards; although these are not statutory guidance, many of them have that status by default or reference from the Approved Documents to the Building Regulations. As yet, neither the Building Regulations nor British Standards address future climate change.

<sup>111</sup> Department for Communities and Local Government. (2012). *Technical Guidance to the National Planning Policy Framework*. London: Department for Communities and Local Government.

<sup>112</sup> HM Government. (2004). Section 19 (1A) of the *Planning and Compulsory Purchase Act*. London: HM Government

# Appendix 2

## Non-mandatory schemes

**Voluntary schemes such as the Building Research Establishment's Environmental Assessment Method (BREEAM) and the Code for Sustainable Homes (CSH) – which is to be wound down – are useful in raising the awareness of practice and standards that go beyond the regulatory minimum.**

In particular, they give clients a way to differentiate themselves in a competitive market with a highly visible, authoritative and internationally recognised quality mark. It also bridges the gap between innovative and mainstream practice, offering a clue, perhaps, about how climate change adaptation can make that shift.

## BREEAM

**The new edition of BREEAM for New Construction, Non-domestic Buildings, published in May 2014, now gives explicit attention to climate change adaptation through the introduction of a new credit: Wst 05 Adaptation to climate change.**

The credit aims to 'recognise and encourage measures taken to mitigate the impact of extreme weather conditions arising from climate change over the lifespan of the building<sup>113</sup>.'

Climate change is also considered in the assessment of other credits relating to thermal comfort, passive design analysis to support low carbon design, planting selection, and reducing surface water runoff.

## CSH

The relevant credits for the CSH, which is due to be wound down, were:

- Code for Sustainable Homes: Wat 1 Indoor Water Use, Wat 2 External Water Use, Sur 1 Management of Surface Water Run-off from Developments, Sur 2 Flood Risk, Hea 3 Private Space, and Man 1 Home User Guide.

<sup>113</sup> See BREEAM. (2014). *BREEAM UK New Construction, Non-Domestic Buildings: Technical Manual SD5076: 0.1 (DRAFT)*. <http://www.breeam.org/page.jsp?id=301>

# Appendix 3

## How to discuss climate science with your client

**‘Climate is what you expect, weather is what you get’ – Robert A Heinlein, *Time Enough for Love*, 1974 – often quoted by meteorologists.**

Clients need the science of climate change and the consequent need to adapt explained to them from first principles in a way that accurately expresses its relative importance. As the brief crystallises and building designers’ work demonstrates the value of measures, so the level of technical detail communicated should increase.

### Climate and weather

**First, the distinction between climate and weather must be stated. Climate is the averaging out of weather into discernable trends. So, for example, to say that summers are hotter than winters describes the climate.**

Within the general trends described by climate is huge variability – the weather. A dry summer can have extremely wet days (or even minutes) in it. There is no limit to these extremes, but their average frequency, or ‘return period’ (usually measured in years), is thought to be influenced by climate trends.

Building designers must be able to test their designs against plausible future weather – especially plausible extremes – as derived from climate trends.

### Headline trends

The headline climate trends in the UK are:

- warmer, wetter winters
- hotter, drier summers
- rising sea levels
- more extreme weather events.

These climate projections are produced by the Met Office Hadley Centre and are known as UKCP09 (UK Climate Projections 2009), providing climate information and probabilistic projections for 25km square grids across the whole of the UK.

The scenarios in UKCP09 – High, Medium and Low – map onto those used by the Intergovernmental Panel on Climate Change (IPCC), whose equivalent designations are, in order, A1F1, A1B and B1. They reflect plausible climate models as influenced by economic, social, demographic and technological factors and their consequent effect on greenhouse gas emissions.

Very simply, the projections illustrate three different scenarios for successive 30-year time periods at, usually, three levels of probability (10%, 50% and 90%) relative to a 1961-1990 baseline.

### Figures that allow room for error

**To clarify, a projection of, say, 5°C at the 10% level means that the temperature has a 10% (or ‘very unlikely’) chance of being less than 5°C.**

A projection of, say, 30°C at the 90% level has a 90% (or ‘very likely’) chance of being less than 30°C.

A 50% probability is called the central estimate and is ‘as likely as not’.

In other words, the projections are probabilistic – they attempt to quantify the likelihood that any projected value will not be exceeded. This is more useful than giving a single mean figure in that it tells you how much room for error there is. However, it also makes the projections harder to interpret for building designers, clients and other stakeholders.



## Appendix 3

### Variables

The projected variables included in the UKCP09 data are shown in Figure 19.

<b>Over land:</b>
• mean temperature
• mean daily maximum temperature
• mean daily minimum temperature
• warmest day of the season (99th centile of daily maximum temperature in a season)
• coolest day of the season (1st centile of the daily maximum temperature in a season)
• warmest night of the season (99th centile of the daily minimum temperature in a season)
• coldest day of the season (1st centile of the daily minimum temperature in a season)
• precipitation rate
• wettest day of the season (99th centile of daily precipitation rate in the season)
• specific humidity
• relative humidity
• total cloud
• net surface long-wave flux
• net surface short-wave flux
• mean sea-level pressure
<b>Over marine regions:</b>
• mean air temperature
• precipitation rate
• total cloud
• mean sea-level pressure

**Figure 19:** Variables projected in UKCP09 over land and marine regions

### Information currently missing from the climate projections

**Wind direction and speed<sup>114</sup>, storm events, soil moisture, snowfall, and allowing for changes in urban heat island<sup>115</sup> effects are missing from these lists. In their very useful *UK Climate Projections: Briefing Report*<sup>116</sup>, UKCIP says:**

“Projected changes in storms are very different in different climate models. Future changes in anti-cyclonic weather are equally unclear. We have been unable to provide probabilistic projections of changes in snow. The Met Office Hadley Centre regional climate model projects reductions in winter mean snowfall of typically –65% to –80% over mountain areas and –80% to –95% elsewhere.”

### Extreme weather events

**According to the IPCC Fourth Assessment Report, global warming will result, in many regions, in increases in the frequency and intensity of weather extremes<sup>117</sup>. Globally, this trend is likely to continue to the end of this century (see Table 3 for details). The IPCC *Summary for Policymakers*<sup>118</sup> is careful to be precise in its use of descriptions, which are all formally defined. It says:**

“It is very likely that the number of cold days and nights has decreased and the number of warm days and nights has increased on the global scale. It is likely that the frequency of heat waves has increased in large parts of Europe, Asia and Australia. There are likely more land regions where the number of heavy precipitation events has increased than where it has decreased. The frequency or intensity of heavy precipitation events has likely increased in North America and Europe. In other continents, confidence in changes in heavy precipitation events is at most medium.”

<sup>114</sup> Since the launch of UKCP09, probabilistic projections for wind speed have been produced but cannot be used to project plausible future weather. <http://ukclimateprojections.metoffice.gov.uk/22701>

<sup>115</sup> Urban heat island' describes the phenomenon of cities being significantly warmer than their rural surroundings, particularly at night. It is caused by the greater concentration of heat sources such as buildings and the storage of solar energy in the urban fabric. During heat waves, UHIs can be a serious risk.

<sup>116</sup> Jenkins, G. J. (2009). *UK Climate Projections: Briefing Report*. Met Office Hadley Centre.

<sup>117</sup> Øystein Hov, U. C. (2013). *Extreme Weather Events in Europe: preparing for climate change adaptation*. Norwegian Meteorological Institute.

<sup>118</sup> Intergovernmental Panel on Climate Change. (2013). *Summary for Policymakers*. In IPCC, & T. D.-K. Stocker (Ed.), *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.

Phenomenon and direction of trend	Likelihood of further changes Early 21st century	Likelihood of further changes Late 21st century
Warmer and/or fewer cold days and nights over most land areas	Likely	Virtually certain
Warmer and/or more frequent hot days and nights over most land areas	Likely	Virtually certain
Warm spells/heat waves. Frequency and/or duration increases over most land areas	Not formally assessed	Very likely
Heavy precipitation events.	Likely	Virtually certain
Increase in the frequency, intensity, and/or amount of heavy precipitation	Likely over many land areas	Very likely over most of the mid-latitude land masses and over wet tropical regions
Increases in intensity and/or duration of drought	Low confidence	Likely (medium confidence) on a regional to global scale
Increases in intense tropical cyclone activity - A major cause of extreme wind speeds and heavy precipitation especially in wintertime.	Low confidence	More likely than not in the Western North Pacific and North Atlantic
Increased incidence and/or magnitude of extreme high sea level	Likely	Very likely

**Table 3:** Extreme weather and climate events: Global-scale assessment of projected further changes for the early (2016–2035) and late (2081–2100) 21st century. (Adapted from Table SPM.1 of the IPCC Summary for Policymakers (2013))

However, extreme events happen irregularly and cannot be predicted directly from the UKCP09. In other words, they are difficult to model. Not only are we unable to predict them, as yet the complex science of how factors interact to cause some extreme weather events is still in its early days<sup>119</sup>.

### Return periods

**That said, dynamic modelling does allow us to project changes in the return period. For example, what is now a one-in-50-year event may become a one-in-five-year event by the end of the 21st century<sup>120</sup>.**

The insurance industry has a keen interest in this area. In a recent study commissioned by the German Association of Insurers (GDV), future insured losses caused by storms and floods were modelled, producing very robust results that all show increases in insured losses caused by climate change.

This kind of evidence allowed PricewaterhouseCoopers<sup>121</sup> to predict that:

“The biggest climate risk faced by the UK is flooding, particularly in the form of winter floods; the incidence of extreme storms is likely to increase; rising sea level will present challenges to coastal communities during the second half of the century; and heat waves and droughts will increase in frequency, particularly in the south of the country.”

Many of the D4FC projects saw extreme weather events as their chief threat. For example, the Glanford Park team reported:

“Based on the climate projections and thresholds it appeared that key climate impacts for the site were associated with the extremes: increased flooding (river and surface) associated with peak rainfall and heatwaves.”

<sup>119</sup> A recent report (Thomas C. Peterson, 2013) found it difficult to attribute causes (or combinations of causes), and certainly not anthropogenic climate change, to 12 extreme weather events in 2012. The connection may be simply buried in the statistical noise, but for now our models are not powerful enough to pick it out. This has not stopped significant political figures and respected commentators from assuming the connection. [www.ametsoc.org/2012extremeeventsclimate.pdf](http://www.ametsoc.org/2012extremeeventsclimate.pdf)

<sup>120</sup> *Extreme Weather Events in Europe: preparing for climate change adaptation (2013)*

<sup>121</sup> PricewaterhouseCoopers. (2013). *Is UK Plc climate-ready?* Business Green.

## Appendix 3

### The hazards of climate change

**The hazards to buildings from climate change are spelt out in Innovate UK's Design for Future Climate: Opportunities for adaptation in the built environment report<sup>122</sup>. Inevitably, they have ended up as information-packed matrixes, one for each of the three risk categories: comfort and energy performance; construction; and managing water.**

The matrixes can be viewed at the end of the relevant chapters at <https://connect.innovateuk.org/web/design-for-future-climate/>

They successfully provide a structure for the topic in a way that makes sense to building designers, and indeed were used as the starting point for most of the designers involved in the D4FC projects.

However, they are indicative only, and almost by definition will be incomplete, especially as time elapses. Also, while these matrixes make sense to building designers, they are less valuable to construction clients, whose interest in hazards is dominated by the need to know what it means for them. They need to know what are the risks to their purpose, people, operations and assets, and how they should respond.

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<sup>122</sup> Gething, W. (2010). *Design for Future Climate: Opportunities for adaptation in the built environment*. Swindon: Innovate UK

# Appendix 4

## Profiling buildings' vulnerability to climate-change risks from a client's perspective

**Quickly assessing a building's vulnerability and thus its ability to benefit from adaptation requires a look at the fundamental qualities shared by all buildings. This exercise has the added advantage of forcing building designers to think of the building from their clients' perspectives. The fundamental qualities are:**

### 1. The ability of the building to serve its purpose.

Clients want their buildings to keep the weather out. This is about the building's life expectancy, site, orientation, ground conditions, exposure to hazards, which, depending on how benign they are, can make clients more or less interested in adaptation.

### 2. The health, safety and well-being of occupants in the building.

If only to comply with health and safety legislation, clients want people on their premises to be safe. These can be tenants or staff, older people or children, family and loved ones, or known or unknown future occupiers. Clearly, the risk of death or injury is a priority for every client, and the more people there are likely to be, the more of an impact it could be. However, less significant factors come into the equation. For example, avoiding overheating might be especially important for a certain group of workers, making it more likely that clients will be interested in adaptation.

### 3. The continuity of operations carried out in the building.

Clients do not want what they do to be interrupted, whether it is retail sales, business-critical office work, eating and sleeping, education, or delivering treatment for the ill. Some of these operations might be more critical for clients than others, which will ramp up their interest in adaptation.

### 4. The security of contents in the building.

Clients want the contents of their buildings – business-critical computer servers, perishable produce, expensive goods, life-saving equipment, or just home furnishings – protected. Insurance might not be suitable if the impact of not having the contents is severe, in which case adaptation might be a better investment.

The more vulnerability you can identify, the more the building will benefit from adaptation. However, even if the benefits are overwhelming, many other factors will affect whether or not they can become part of a building designer's brief. These include the client's incentive to do so, and building design teams' inclinations or abilities to take on the challenge, as explored in Sections 2 and 3.



## Appendix 4

The Betws Colliery Washery team used a simple table to work out their development's vulnerability and potential consequences in broad brushstrokes before attempting to quantify the extent of risk. This information framed the opportunities for designing adaptation measures and a coherent strategy, which involves detailed analysis and professional skill.

Risk Summary			
Climate change theme	Vulnerabilities	Impact	Potential consequences
Designing for comfort	Overheating	Internal environment unpleasant and occasionally intolerable	Loss of trading stock damage
	Energy use	Increased energy consumption for cooling	Increased running cost for business potentially threatening viability
Construction	Severe storms	Wind damage to walls and roof	Cost and inconvenience of repair loss of trading stock damage
Managing water	Severe storms	Water penetration through roof	Cost and inconvenience of repair loss of trading stock damage
	Likely over many land areas	Very likely over most of the mid-latitude land masses and over wet tropical regions	
Managing water	Severe storms	Water penetration through roof	Cost and inconvenience of repair loss of trading stock damage
	Severe storms and intense and prolonged winter rain	Flooding of car parks and entrance to buildings	Loss of trading
Green infra-structure	UHI exaggerated	External environment unpleasant and occasionally intolerable	Loss of trading
	Depletion and degradation	Health of eco-system	Human habitation less tolerable



# Appendix 5

## Strategies for controlling buildings' vulnerability to climate change

**Designing adaptation measures or adaptive capacity together are just one class of control in a hierarchy of responses to climate change hazards.**

All play their part in a properly thought-through adaptation strategy, and a mix of responses is likely to be appropriate for the average building. As the Modern Built Environment Knowledge Transfer Network's report<sup>123</sup> says:

"Technical measures are most effective when complemented and reinforced by policy and risk-transfer measures."

Building designers have a role to play in most of the controls for buildings' vulnerability because of their expertise. For example, before knowing whether to insure a building-related risk, you must know the likelihood and impact of a hazard, and the cost of alternative controls (such as adaptation measures). As professionals with an intimate knowledge of how buildings work, building designers will have most affinity with 'adaptation' as a response to identified vulnerability. However, it is by no means always the preferred option for clients, particularly as building works involve disruption and can be a significant capital cost.

**Elimination** – unfortunately, climate change hazards cannot be eliminated. However, this control is included because it highlights the importance of mitigation. In a sense, the effort to mitigate climate change by cutting carbon emissions is a global effort if not to eliminate then to reduce the risk.

**Avoidance** – avoid the risk altogether by building elsewhere. The optimum response to building on a flood plain, for example, could very well be not to. The decision is not always as straightforward as it seems, however, especially where the frequency of floods is low and the location is important to the client but the land and property values in it are otherwise uneconomic. The risks of building in the flood plain against the costs of building just outside it might just be worth the gamble.

**Transference** – insure against the risk or share it with other stakeholders. This works well for high impact but low likelihood risks such as, in the UK, one-in-100-year storms. As the likelihood of such events increases with climate change, insurance companies will be less willing to take on the risk. The trend therefore will be for rising insurance premiums, which could drive more physical adaptation, creating a market for building designers' adaptation services.

**Adaptation** – alter existing buildings or design new buildings to either control the hazard, or to build in the adaptive capacity to do so.

**Management** – change the way that operations are undertaken on the premises to cope with or minimise the risk. For example, a small manufacturer might reduce the numbers of employees at work in a part of their building that regularly overheats.

**Behavioural change** – find new ways of behaving on the premises without any change to the work routines. For example, relax the office dress code during hot weather.

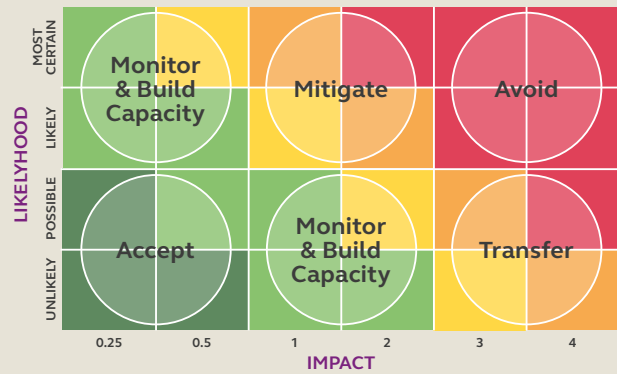
**Accept the risk** – do nothing. Again, this may be rational if the hazard is comparatively rare and the impacts negligible. Of course, this strategy can only be adopted with confidence once the risks are understood.

<sup>123</sup> Knowledge Transfer Network, Modern Built Environment. (2013). *Guidance for making the case for climate change adaptation in the built environment*. Climate Ready

## Appendix 5

The Glanford Park team developed a simple framework (opposite) to allocate strategies based on their assessment of the risk from relevant hazards, which accounted for the views of all financial stakeholders. The five responses were:

- **Avoid:** Stakeholders take action not to be involved in a risk situation.
- **Transfer:** Stakeholders take action to share burden of loss/benefit with another party, for instance insurance or service level agreements can be deemed to be transfer actions.
- **Mitigate/adapt:** Stakeholders take action to reduce or eliminate negative consequences.
- **Monitor and build capacity :** Stakeholders take action to monitor any changes to the risk and support staff/others in developing skills to respond effectively.
- **Accept:** Stakeholders do not perceive the risk to be significant and make the decision to take no action. (Deloitte, 2013)



In their report, the Modern Built Environment KTN recommended that risks should be categorised as follows:

Category of Risk	Description	Action
<b>Cat 1</b>	<p>There is an immediate threat from them under current conditions</p> <p><b>OR</b></p> <p>Adapting to the threat involves long-term investment, lengthy implementation/large financial outlay</p> <p><b>AND</b></p> <p>There is a high value at stake if the wrong decision is made.</p>	Development must be adapted to the climate risks
<b>Cat 2</b>	There is an immediate threat from them under current conditions.	Monitor the risks and respond if they change for the worse.
<b>Cat 3</b>	Climate change risks are not a risk factor for the development.	None.

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