Your home in a changing climate

Retrofitting Existing Homes for Climate Change Impacts

Report for Policy Makers

LONDON climate change PARTNERSHIP

Sustainable Development Round Table for the East of England

South East Climate Change Partnership

February 2008

This research was commissioned by the Three Regions Climate Change Group and undertaken by Arup.

ARUP

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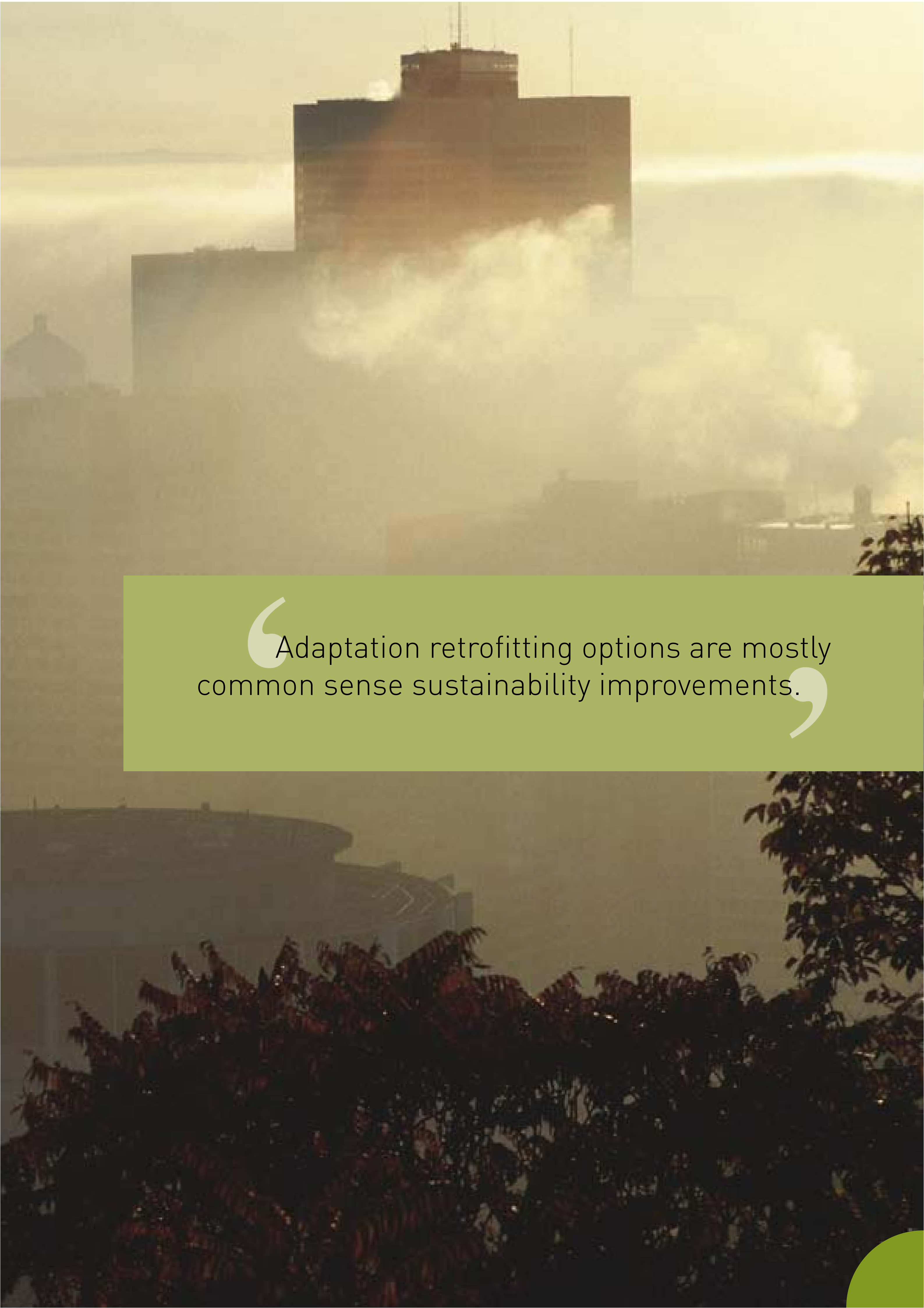


‘Adaptation retrofitting options are mostly common sense sustainability improvements.’

Foreword

It is accepted that we are committed to at least 40 to 50 years of climate change, whatever we do now, and in the future, to reduce our CO_2 emissions.

Households will be particularly affected by climate change. Summer heatwaves will make homes uncomfortable, while more frequent and severe flooding and reduced water availability may expose homes and their occupants to greater risks unless action is taken.

The three regions of London, the East and the South East of England are projected to see the most dramatic climate change impacts in the UK. We have very recent experience of the devastating effects of flooding (2007), drought (2006) and heatwaves (2003) and we can expect more of the same as climate change progresses.

The three regions have a housing stock of more than 9 million homes – homes that were designed and built with a different climate in mind. With housing stock turnover at about 1 per cent per annum, it is clear that the majority of homes, even by 2050, have already been built. It is therefore important that we act now to retrofit and adapt our existing homes to increase their resilience and long-term sustainability in the face of increased climate change.

This groundbreaking study through the Three Regions Climate Change Group is a first step towards ensuring that our homes are comfortable and sustainable now and in the long terms. Our study clearly shows:

- That it is possible and cost effective to increase the resilience of the existing housing stock.
- That small changes can have a big impact, particularly when it comes to saving water and reducing CO_2 emissions through tackling overheating.
- That mitigation and adaptation measures can be, and should be, successfully integrated, with adaptation measures also delivering significant CO_2 reductions.

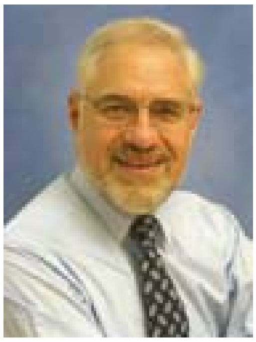
Perhaps most importantly we need to ensure that retrofitting is delivered by working with trained providers to ensure that all professionals have a suitable "adaptation skill set".

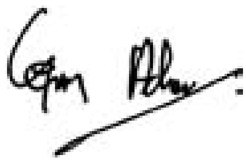
This study is aimed at policymakers, housing professionals and householders. We are mindful that leadership from all levels of Government and society will be required if retrofitting is to be achieved successfully on a large scale.

We hope you find the study interesting and relevant, but more importantly, we strongly recommend that you start acting on the recommendations and findings. We look forward to working with you in the future to achieve this.

John Rumble
Chair, Climate Change
Steering Group
East of England Sustainable
Development Roundtable

Graham Tubb MBE
Chair, South East Climate
Change Partnership





Gerry Acher CBE LVO
Chair, London Climate
Change Partnership

Headline findings

This report makes the case for adapting our existing homes in the three regions of London, the East and the South East of England to ensure they are liveable and comfortable in a changing climate. It makes it clear that by adapting our existing homes we can:

- Ensure our homes are resilient to flooding and can be repaired and reoccupied rapidly and relatively inexpensively following a flooding event.
- Improve water efficiency in every home in the three regions using simple cost-effective measures that save water, energy and carbon. Additional energy savings can be achieved with measures that reduce hot water consumption.
- Effectively address overheating risk without significantly increasing CO_2 emissions.

The report also states that adaptation to future climate impact should be an integral part of housing stock improvement. This can be done through:

- Existing Local Authority and social housing renewal programmes. Eg. Decent Homes, post 2010.
- Large-scale retrofitting programmes.
- Homeowner DIY projects.

Why is adaptation important?

There are 21 million people living in nine million homes in the three regions. Of these homes, the overwhelming majority - if not all - were designed for climatic conditions prevalent at the time of build. These conditions have changed and projections of changing climate over the coming decades, in particular flooding, water stress and overheating, suggest that the climate will continue to change adversely affecting these homes.

Although progress is being made on designing new homes for our changing climate, housing stock turnover is low. It is predicted that by 2050, only 30 per cent of the total stock will have been constructed post-2006. Therefore, widespread adaptation of existing homes is crucial to ensuring that they are comfortable, marketable, resource efficient and fit for purpose in the present and the future.

A key point is that the households most vulnerable to climate change impacts will be the disadvantaged and who are the least able to adapt.

What can be done to adapt our homes?

- Existing homes can be adapted to improve their comfort, resilience and energy and water efficiency.
- Cost-effective adaptation solutions are available that will reduce the scale and scope of climate change impacts on our housing stock.
- There are many low and no-cost measures that can be taken to improve the performance and comfort of the home as well as save the householder money.

However, uptake of climate change adaptation measures is low because of the lack of information and awareness about adaptation options and access to appropriate advice and skilled installers.

How can we make it happen?

- Strong leadership from all levels of government is needed to facilitate the widespread uptake of adaptation. There remains a lack of a single, focused responsibility for supporting and promoting adaptation in existing homes, which needs to be addressed.
- Clear direction and coordination is required to deliver simple messages and facilitate the introduction of appropriate measures, including through policy change, grants and incentives, both non-financial and financial.
- Adaptation should be integrated with the carbon reduction agenda for homes. This will lead to both additional carbon savings and a more robust and resilient housing stock.
- The key actors to educate, encourage and enable householders to make appropriate choices are: policy makers, non-governmental organisations (NGOs), installers, suppliers, professional institutions and housing market institutions.
- In particular, government should work with training providers to ensure professionals have a suitable 'adaptation skill set'.

Action by government, landlords from the social and private sectors, owner-occupiers, DIY suppliers and associated professionals will help to ensure that our existing homes will be more resilient to the challenge of climate change and continue to be sustainable and liveable over their designed life.

Executive summary

This study was commissioned by the Three Regions Climate Change Group. It explores the potential for retrofitting to introduce adaptation measures to improve the performance of existing homes against three impacts of climate change: flooding, water stress and overheating.

As part of the project, a review of climate change projections for the three regions and measures for adapting existing homes to the three impacts was undertaken. A series of consultation forums were held to evaluate existing understanding of and attitudes to the need to adapt to climate change. Barriers to the widespread uptake of adaptation were assessed for individual householders and those in a position to enable and encourage adaptation. Three costed case studies were produced to show how existing homes could be effectively retrofitted with appropriate measures.

These inputs fed into the content of this high-level policy report that identifies the key findings from the study as well as the next steps towards achieving widespread adaptation. This includes action required from government, professional installers and their institutions, suppliers, housing market institutions and NGOs.

The contribution of our housing stock to CO_2 emissions has been well documented, and innovative measures to reduce future CO_2 emissions from new stock are being implemented. However, regardless of the success of these efforts, our climate will continue to change for the next 40 to 50 years as a result of past and current emissions and will change beyond depending on future emissions. Adapting our current housing stock is therefore essential in order to make homes and their occupants less vulnerable to the impacts of climate change and to keep emissions from housing low in the longer term.

The three regions covers an area of 400,000km^2 in the south east of the UK, with a boundary running from the Isle of Wight to the Wash. The area has a population of 21 million people, living in nine million homes. These buildings are extremely variable in terms of size, age of construction, location, occupancy and tenure.

Housing stock in the three regions was largely constructed over the course of the 20th century. It was designed for the climate that prevailed at the time, rather than the climate we can expect to experience now and over the coming decades. Combined with our increasing population, and increasing expectations of quality of life, this means that much of our housing stock will not deliver required levels of comfort, safety and resource efficiency in the 21st century. It is projected that 70 per cent of housing stock in 2050 will consist of the buildings that exist today.

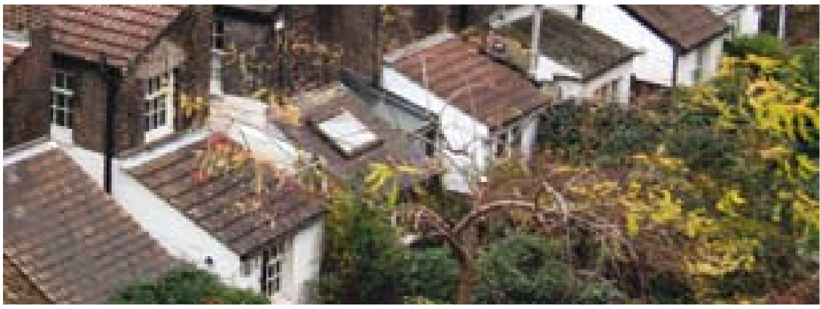
Key impacts of climate change

The UK's climate has already started to change, and these changes are projected to accelerate. The three regions are projected to see the most dramatic climate change impacts in the UK, particularly flooding, water stress and overheating.

Flooding causes widespread damage and disruption to homes, as has been shown by the events of summer 2007. Average insurance claims for properties affected by these floods were £50,000, and the overall bill will be in excess of £3 billion. It is estimated that by 2050 flooding will become more frequent and intense as a result of climate change: in real terms flood-related damage could double in an average year, and triple in an extreme year, compared to current levels. Those properties that currently experience flooding are projected to suffer more frequently and severely, and previously unaffected properties may experience flooding. Adapting to minimise the impact of flooding will help reduce the cost and disruption of these events.

Water stress is already a familiar issue across the three regions area, with the south east, London, and parts of the east region all being areas of water stress. Potentially longer dry periods, combined with increasing demand associated with projected population, agricultural, horticultural and commercial growth, will put more pressure on shrinking water resources. Estimates suggest that an increase of 10-15 per cent in reservoir capacity will be required to serve the needs of the population. In addition, over-abstraction is already causing environmental damage in parts of the three regions, and reduced rainfall and increased consumption will aggravate this situation. Adapting existing homes will help to ease the severity of this - retrofitting homes with water-efficient measures, such as those described in our case studies, could save 150,000 mega-litres per year across the three regions area. This is equivalent to the total domestic water use in three cities the size of Birmingham.

Overheating as a local impact of climate change is not well understood. Projections suggest that by 2050, we will experience a hot summer like that of 2003, when temperatures topped 38°C, every other year. During prolonged periods of high temperatures, heat stress becomes a major cause of increased morbidity and mortality of vulnerable populations, especially the elderly, the very young and those in poor health. In London, around 600 excess deaths in the hot summer of 2003 were attributed to the heatwave, with 2,000 deaths across the UK. High temperatures can be ameliorated by air conditioning, but the associated energy use will generate CO_2 emissions that will further exacerbate global warming. For example, mechanical cooling of half the homes in the three regions area could result in an additional million tonnes of CO_2 emissions. Where homes are kept cool using passive and low-energy measures (such as fans), temperatures are reduced and CO_2 emissions are not significantly increased.



Adapting our homes

In order to reduce the impacts outlined, it is essential to adapt the housing stock in the three regions to improve long-term resilience to climate change. However, there is no 'one size fits all' solution. Variations in risks associated with each of the three key impacts, the capacity of the householder to take action, and the construction of a building mean that adaptation measures for each property need to be assessed individually.

However, our case studies on typical buildings in the three regions area show that cost-effective measures are currently available to increase the robustness of buildings in the face of climate change. This will not only make homes safer, more comfortable places which consume fewer resources; it will also save householders money and reduce CO_2 emissions. For example, fitting a water-efficient shower head not only saves water but reduces the amount of energy needed to heat water.

Delivering adaptation

In contrast to new buildings, the condition of existing homes is the responsibility of a complex range of independent actors, including the individual householder. However there is no regulatory framework to govern this process.

Consequently, clear leadership is required for successful adaptation of our homes to climate change. Delivering adaptation requires coordination between different agencies working together to communicate the message, enable and encourage action, prime the market, and support the efforts of householders to adapt their homes. Policy makers, planners, businesses and others have a vital role to play in helping households to adapt. Elements required in order to ensure this happens include:

- Campaigning: to inform and persuade the public of the need to adapt. A strong, clear message about the local impacts of climate change - flooding, water stress and overheating - needs to be shared, along with the message that adaptation can improve quality of life now and in the future. Wherever possible, adaptation messages should also be included when mitigation messages are being presented, for example through collaboration with existing programmes and campaigns such as 'Decent homes', 'DIY planet repairs', and 'Beat the drought'.
- Market transformation: steps must be taken to prime the market with appropriate adaptation technologies. Available mechanisms to encourage adaptation must be exploited and new ones developed, for example incentive schemes, grants and professional advice services. Options might include reducing VAT on refurbishment to bring it into line with new developments, reducing stamp duty, subsidising adaptation measures through taxation, and giving reductions in council tax for adapting a home.

- Registered social landlords and local authorities are responsible for 1.6 million homes in the three regions. Encouraging uptake in this sector through grants and incentives represents a substantial market for adaptation technologies, with the potential for this to help reduce the cost of adaptive measures in the market as a whole.
- Availability of resources and information: this would enable the public to assess their personal risk, access advice and guidance, and assess the economic benefits of adaptation. It could be done locally, for example through installers and suppliers, including DIY stores.
- Engagement with professional institutions: including those within the housing market, and professional installers and suppliers to ensure that installers have the skills to fit adaptation measures. This will involve working closely with training providers so that climate change adaptation is embedded in their programmes.
- Professionals: surveyors, architects and Housing Information Pack assessors already have access to properties, and may be trusted advisors. They need to be informed and encouraged to deliver advice on the need and options for adaptation to climate change impacts.
- Housing market institutions: insurers and mortgage lenders have contact with householders and are already acting to encourage adaptation, particularly in response to flooding. However, the market is competitive, which can place constraints on the ability to influence householders.
- Schools and universities: these provide an opportunity to include climate change in the curriculum, reaching the next generation of householders and professionals, and to access and educate families through their children.
- Special attention paid to vulnerable communities and individuals: vulnerable groups are the most likely to be adversely affected by the impacts of climate change, and they are the least able to act. Appropriate measures should be put in place to enable adaptation uptake by vulnerable households. Programmes already exist to assist these groups and mechanisms need to be identified to ensure that adaptation measures are incorporated into existing schemes, or covered by new schemes.

Next steps

The impacts of climate change are already with us, but awareness of the need to adapt, and the measures that can be taken, is low. Achieving adaptation is made more complex by the lack of focused responsibility for supporting and promoting adaptation in the domestic sector. Clear leadership is required to create the right environment for professional and installer bodies, as well as the supply chain, to provide adaptation solutions. By acting now we can make housing stock in the three regions more resilient to the impacts of climate change.

‘One-off events are not going to be one-off events any more.’

Our changing climate

It is now clear that the earth's climate is changing rapidly. Scientists have concluded that these changes are a result of the accumulation of greenhouse gases (GHGs) in the atmosphere arising from human activity, principally carbon dioxide (CO_2) from the burning of fossil fuels. In the UK, residential buildings are responsible for 27 per cent of national CO_2 emissions, through the provision of heating, lighting and electrical power for appliances.[1]

The most comprehensive projections for global climate change are given in the Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, published in 2007.[2] This makes it clear that urgent action is needed now both to reduce our CO_2 emissions and to adapt to the inevitable impacts of climate change.

Research into future climate scenarios for the UK is coordinated by the UK Climate Impacts Programme (UKCIP).[3] Key projections for the UK for the time period 2071-2100 (2080s) are:

- Winters will be warmer, with a mean temperature increase of 1 to 3.5°C.
- Summers will be hotter. The mean temperature will rise by 1 to 5°C.
- In summer 'extremely' warm days will occur more frequently. Under the high emissions scenario, the maximum temperature could exceed 30°C on one in ten days during the summer in the three regions.
- Winter precipitation will increase by up to 35 per cent.
- Summer precipitation will decrease by up to 60 per cent.
- Winter storms and heavier winter precipitation will become more frequent.
- Soil moisture content will be reduced in spring, summer and autumn. The greatest decrease, of up to 60 per cent, will occur in autumn because of drier, hotter summers.
- Snowfall will be significantly reduced, by at least 30 per cent and possibly as much as 100 per cent. Large parts of the country could experience long runs of snowless winters, particularly under the medium–high or high emissions scenarios.
- Sea-levels will rise, with the greatest changes in the south.

These changes will mean that the likelihood of 'extreme weather' such as droughts, heatwaves and flooding will increase. The 2004 Foresight Future Flooding report[4] estimates that the number of flood events could increase by between two and twenty times by the end of the 21st century.

The UK, including the three regions has experienced changes in its climate since most of the homes were constructed. These changes are reflected in long-term observational records that show[5]:

- Ten of the warmest years on record have occurred since 1990, with July 2006 being the warmest month on record, autumn 2006 the warmest autumn, and April 2007 the warmest April.
- August 2003 was the hottest ever maximum temperature in the UK (38.5C at Faversham, Kent).
- The average duration of summer heat waves has increased by between 4 to 16 days in all regions of the UK since 1961.
- There has been a general trend of decreasing rainfall in summer and increasing rainfall in winter with heavier winter precipitation events.

UKCIP02 projections at regional level suggest that for the impacts listed above, changes will occur faster and be more extreme in the south and east of the country. This means that the three regions are projected to be affected, and more severely, than other parts of the UK.

Figure 1 shows projections for changes in annual average daily temperature and summer precipitation in the three regions.

UKCIP uses a range of emissions scenarios to project the extent of future climate change, with higher emissions resulting in greater change in the longer term. However, in the medium term (up to the 2050s), there is no significant divergence in the projections of temperature increase because the global warming that will be experienced is primarily dependent on historical and current emissions. Therefore action to reduce greenhouse gas emissions in order to stabilise atmospheric concentrations at safe levels - climate change mitigation - is urgently required. At the same time though, adaptation will also be needed to cope with the unavoidable climate changes that will occur.

Retrofitting existing homes to enable them to better cope with impacts of climate change is an important part of climate change adaptation. It is vital that our homes continue to be healthy, comfortable places to live and do not suffer from the effects of flooding, from water shortages during droughts, and from overheating. This document assesses effective measures to adapt the existing three regions housing stock.

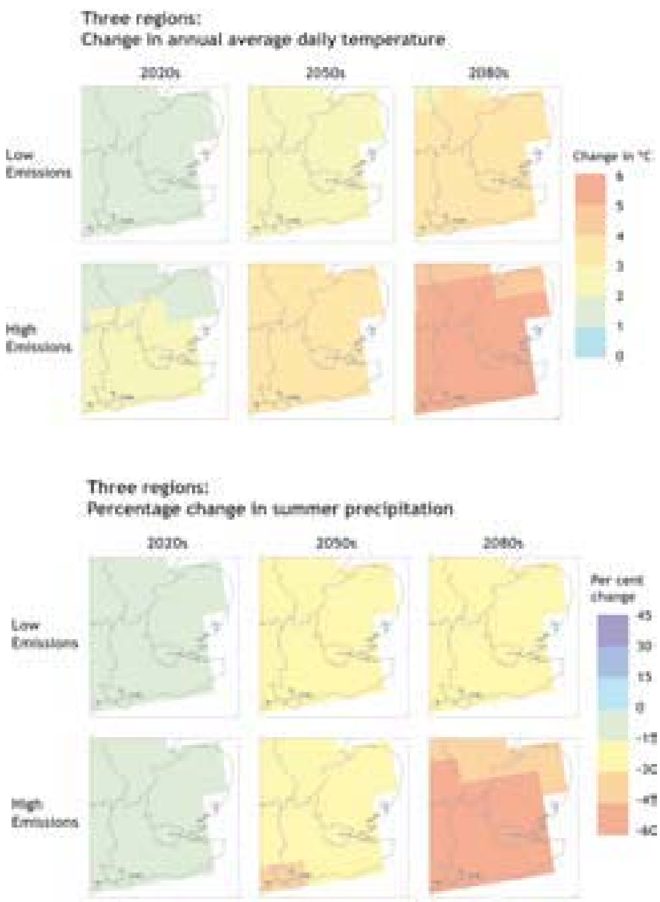


Figure 1 Three regions climate change projections from UKCIP.[3]

Climate and demographic change in the three regions area

The three regions area incorporates London and east and south-east England. It has a population of 21 million[6] - approximately 40 per cent of the total population of England and Wales - and covers an area of 400,000km_ with a boundary running from the Isle of Wight to the Wash.

All three regions are expected to experience climate change impacts, summarised below and illustrated in Figure 2:

London

- Urban heat island (UHI) effect is expected to exacerbate overheating, as has already been experienced in 2003 and 2006.
- Tidal, fluvial and surface water flooding could result in major financial impacts.
- Already a water stressed area.

East of England

- Flooding is a key impact, though overheating and water stress will be significant.
- UHI is expected to exacerbate overheating in large urban areas.

South East of England

- Already a water stressed area, and increasing levels of development will impose further demands.
- Effects of overheating and flood risks are already being experienced.

Figure 2 The Three Regions. (© UKCIP).

Demographic change

Climate impacts will take place in the context of demographic and lifestyle changes. By 2025, the area's population is expected to approach 24 million people[7] and at the same time, social changes mean that more people are choosing to live alone. These factors will combine to increase the volume and density of new housing across the three regions, placing additional pressure on them to adapt to the impacts of climate change.

Climate impacts

Flooding: Increased urbanisation results in reduced water absorption capacity, leading to more surface water runoff and increased flooding. Many features such as pervious paving, ponds, rainwater butts, and green roofs can be applied to individual homes or groups of dwellings to reduce this runoff, either during construction or after some years of occupation. Planning Policy Statement 25 promotes development located out of flood plains, and for all development to reduce flood risk overall. This can be a particular issue in the reuse of previously occupied sites at risk of flooding, and the development of these must include measures to reduce flood risk.

Water stress: Much of the three regions is already considered to be an area of serious water stress, with careful management required to ensure that current resources are sufficient. Unless a reduction in per capita consumption can be achieved, an increasing population and an increasing number of single person households will bring unsustainable levels of demand.

Overheating: Higher density developments will result in an intensification of UHI effects, which results in urban areas being several degrees warmer than rural areas on summer nights.

Housing stock in the three regions

The three regions domestic housing stock consists of 9,060,000 homes.[9] The stock is extremely variable in terms of size, age of construction and type of accommodation.

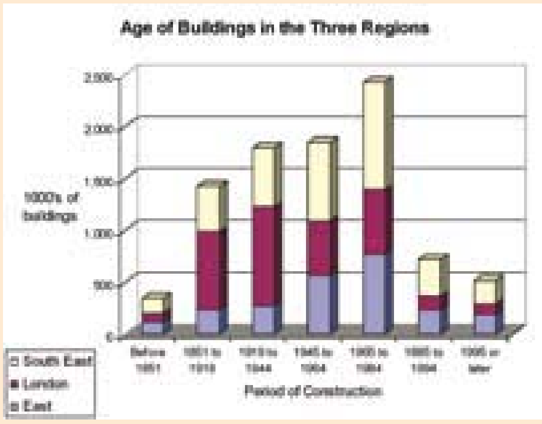
This variability means that the vulnerability of the housing stock to the three impacts identified in this study is also variable on a regional, local and individual building scale. The construction of an individual building will also influence the selection of adaptation measures.

These factors must be taken into account when selecting adaptation measures for each individual dwelling, as they could be counterproductive if installed in an inappropriate building.

Era of construction

Across the three regions, the vast majority of the housing stock was built between 1851 and 1994, with less than four per cent before 1850 and five per cent after 1995.[10]

Each region shows a spread between the ages of dwellings. The east and south-east regions are broadly similar, with the most prolific construction period being between 1965 and 1984, when almost a third of all housing was built. London's housing stock is older, with more than 50 per cent having been built before 1944, and 30 per cent between 1919 and 1944.



- 95% of existing buildings were constructed before 1995,
- 40% were constructed before 1945, and
- 20% were constructed before 1918.

Figure 3 Age of buildings in the Three Regions. (Based on data from CLG).

Flooding Water Stress Overheating

The age of a building can be used to indicate its response to climate impacts, and to suggest the types of adaptation measures that should be considered. For example, cavity walls began to be popular in the 20th century, with brick/ brick cavity walls emerging during the 1930s and being replaced in their turn from the 1950s onwards with brick/ block cavity walls. For older buildings constructed before this period, alternative options for insulating walls, such as internally and externally fitted insulation, should be considered.

Until the 1950s, apartment buildings up to ten storeys high were constructed using load-bearing masonry walls and, later, concrete floors. After that concrete framed buildings were built. Blocks of over thirty storeys began to be constructed in the 1960s, initially of pre-cast concrete, then of in situ concrete from 1970, with steel-framed, concrete floors from the 1990s onwards.[11]

Why do we need to consider widespread adaptation of existing homes?

Stock turnover in the UK is low, with existing stock making up 99 per cent of all homes at any given time. If this rate is sustained, the majority of the housing stock will continue to consist of existing buildings for many decades to come. The Sustainable Development Commission's estimates[12] for the UK's 2050 housing stock suggest that around 70 per cent has already been built.

The buildings constituting existing housing stock in the three regions were designed for the prevailing climate at the time of construction, not the climate we can expect to experience now and over the coming decades. As our climate changes our housing stock will become increasingly inappropriate.

The design of new housing is closely controlled by planning requirements and building regulations, and so a framework exists to guide development towards adapted and low-carbon homes. In contrast, there is no regulatory framework to deal with the adaptation of existing homes, and no single institution has oversight of assessing the state of existing housing, ensuring that they are fit for purpose.

Effects of flooding, water stress and overheating in the three regions

Flooding:

- Properties at risk of flooding in eastern England rises by 48% from 270,000 to 404,000 following a 0.4m sea level rise (assuming no new build between now and 2050).[13]
- The Association of British Insurers (ABI) estimates that if no steps are taken to manage flood risks then the cost of flood damaged homes could rise by £21m annually, with UK insurance costs for extreme weather events in 2050 being around £16 billion.[14]
- The summer floods of 2007 are estimated to have insured costs of £3 billion (costs on 2007 basis), with 165,000 claims in total.[14]

Water stress:

- The UK Environment Agency has estimated that a 10-15 per cent increase in reservoir capacity may be required to address potential water deficits, at an estimated cost of £3 billion.[15]

Overheating:

- The main impact of overheating will be thermal discomfort. However, in extreme or prolonged periods of high temperatures excess deaths will occur. In the 2003 heatwave in the UK, 2,000 excess deaths occurred, 600 of which were in London.[16]
- A rise in the installation of domestic air conditioning will increase CO_2 emissions, the electrical cooling load, noise nuisance and the risks of power cuts.

Without adaptation, climate change impacts will affect the existing housing stock across the whole of the three regions area, with homes potentially becoming uninhabitable.

Effective adaptation options are currently available for all three of the impacts covered in this study. Early, widespread adoption of appropriate adaptation measures will enable existing homes to remain habitable in increasing summer temperatures, be reoccupied more quickly after floods, and consume less water.

> It is not enough for people to know that there are options and that they are good value – they have to believe it and want to adapt.

Flooding

in the three regions

The Environment Agency gathers flood risk data on a national, regional and local area scale. Their National Flood Risk Assessment data[17] can be used to indicate the number of people living in areas with a 'significant' (the chance of flooding in any year is greater that 1.3 per cent (1 in 75). The South East and Greater London regions have the largest population with 'significant' chance of flooding, with around 217,000 and 145,000 people respectively. The East of England Region has around 89,000 people living in areas with this level of risk. (see Figure 4).

The Association of British Insurers (ABI) estimates the number of domestic properties at risk of flooding is approximately 215,000 in the east of England, 190,000 in the Thames area, and 42,000 in Southern England[18] (excluding flooding from coastal and groundwater sources).

Precipitation

Climate change projections suggest an increase in the frequency of intense precipitation events. These cause flash, sewage and fluvial flooding.

Sea level rise

Climate change will lead to sea level rise. In addition, southern England is sinking (and north-western areas of the UK rising) relative to sea level as a result of the last ice age. Sea level rise is expected to affect coastal areas of all the three regions, making them more susceptible to flooding (see Table 1). London and the Thames Gateway's vulnerability is being analysed as part of the Environment Agency's Thames Estuary 2100 project, due for completion in 2010.

Storms

UKCIP02 projects increased wind speeds for the three regions, suggesting a greater risk of storm surges and an increase in the number of wind storms, contributing to increased risk of coastal flooding. The increased flood risk from each factor is summarised in Table 2.

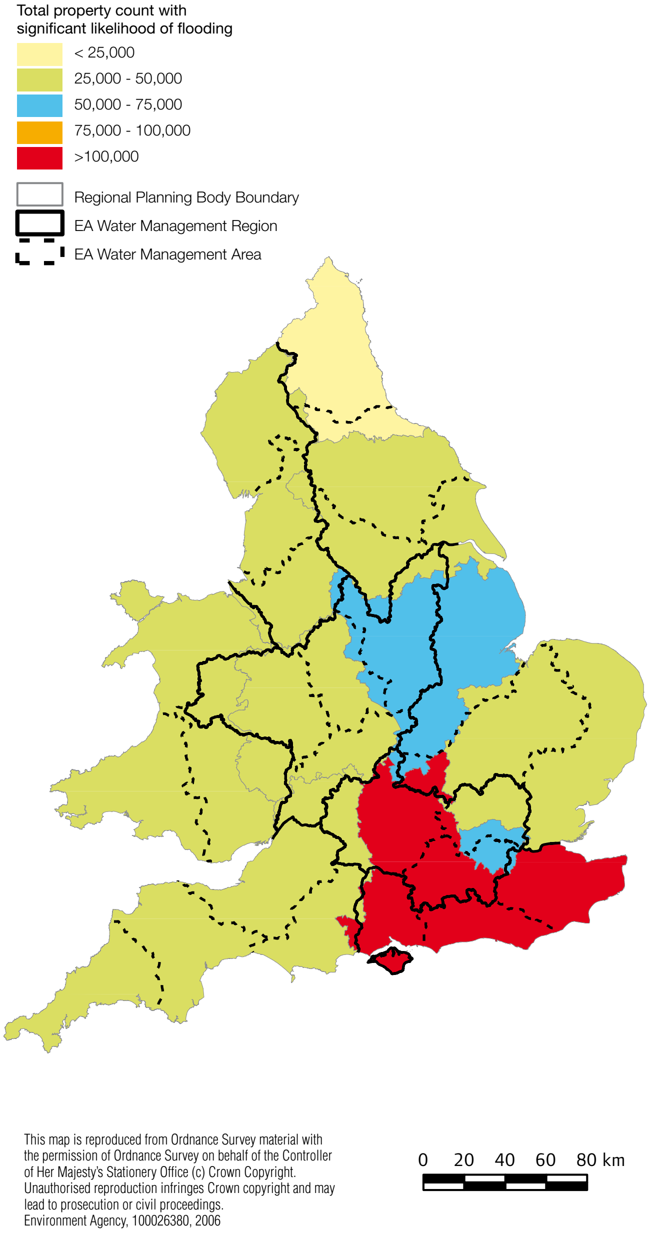


Figure 4 Regions ranked by number of properties in areas with significant (greater than 1 in 75) chance of flooding. (© Environment Agency).

Net Sea Level Rise (mm/yr) Relative to 1990			
1990 - 2025	2025 - 2055	2055 - 2085	2085 - 2115
4.0	8.5	12.0	15.0

Table 1 Recommended contingency allowances for net sea level rise for the east of England, east Midlands, London and south-east England. (South of Flamborough Head).

Source: after Table B.1, PPS25.[19]

Parameter	1990-2025	2025-2055	2055-2085	2085-2115
Peak Rainfall intensity	+ 5%	+10%	+20%	+30%
Peak river flow	+10%	+20%		
offshore wind speed	+ 5%		+10%	
extreme wave height	+ 5%		+10%	

Table 2 Recommended national precautionary sensitivity ranges for peak rainfall intensities, peak river flows, offshore wind speeds and wave heights.

Source: after Table B.2, PPS25.[19]

Flooding - the impacts of failure to adapt

Predicted UK costs for extreme flooding events in any one year are expected to increase from £1,500m today to £4,500m in 2050 for inland floods, and from £5,000m today to £40,000m for extreme coastal flooding events.[20]

Key flooding events in recent years and insurance costs

1990	Storms and coastal flooding in January and February led to £2.1 billion in insurance claims. Over a four-week period, three million claims were received.
1998	Easter floods in 1998 led to the evacuation of 1,500 people from their homes, and a cost to the insurance industry of around £500m.
2000	The UK experienced its wettest autumn for almost 300 years, with heavy rainfall leading to damage of 10,000 properties, and nearly £1 billion in insurance claims.
2007	The UK experienced its wettest summer on record, with significant flooding occuring in the north east and south west of England. Initial figures put the total insurance bill for these floods at £3 billion, with individual domestic claims averaging £50,000.

Table 3 Key UK flooding events (after ABI 2004).[21]

However, the costs of flooding go far beyond the financial - for householders there is the distress of seeing their homes and possessions ruined by floodwaters (which are often contaminated with sewage), and the ongoing inconvenience of being displaced from their homes. It can take three to six months for families to be able to move back into their homes and in some cases may take over a year.

Data on flood risk is publicly available. The Environment Agency's on-line Flood Map[22] gives locations that are considered at risk of flooding from rivers, high tides and storm surges. This is publicly available, with a postcode search facility that allows individual householders to access details of the flood risk to the area of land where their home is located. These show two types of flood risk: those that have a 1 per cent chance of flooding in any one year, and those that have a 0.1 per cent chance of occurring from rivers or the sea.

However, this information does not automatically lead to action by householders. According to the Environment Agency, 'It is of serious concern that still only one person in ten who is at risk makes any sort of advance preparation for flooding'.[23]

© Environment Agency

Flooding - adaptation options and costs

There are a number of adaptation options to protect a home from flooding or make it quicker and cheaper to dry out and repair a home. These measures fall into two categories:

- Resistance measures: preventing or limiting the amount of water entering the home.
- Resilience measures: reducing time and cost of recovering from a flood.

Resistance measures are only effective if all potential entry points are identified and blocked, and so flood resistance measures must be installed as a complete package. For short duration floods, entry points include doors, air bricks, sinks and toilets, and gaps in external walls around pipes and cables. For longer durations, measures will need to be taken to prevent water entering through the walls. Basic measures include repairing damaged mortar, whilst more protection will be obtained by installing waterproof membranes or renders.

In deep floods (over 0.9m), a strategy of excluding water from the home may not be recommended, as imbalance between external and internal water levels can cause structural damage to the walls, and it may be necessary to allow water to enter. For this reason, professional advice should always be sought when installing flood resistance measures.

Packages of resistance measures will vary for every property, but typical examples of measures include:

Measure	Cost
Check the Environment Agency Flood Map	Free
Register with Environment Agency flood warning scheme	Free
Drainage bungs for drains, sinks and toilets	L
Install air brick covers	L
Seal gaps around pipe and cable entries	L
Fit non-return valves on mains drains	M-H
Install demountable door guards	M-H
Move meters and electrical sockets above flood levels	M-H
Install a 'sump and pump' below ground level	H
Raise door thresholds	H
Repoint brickwork on external walls	H
Apply waterproof render to walls	H
Install waterproof membrane on external walls	H

Cost bands:

Free	**L** -	Low (£1-£100)
	M -	Medium (£101 - £1000)
	H -	High (£1001+)

Cost benefit of installing resistance measures:

- For a shallow flooding event, smaller properties can be protected for as little as £2,300, while recovering from a flood may cost from £4,500 to £23,000.
- For high-level floods, a package of resistance measures may cost from £20,000 to £40,000, but this may still be recovered in a single flooding event.
- The cost of a flood may be covered by insurance, but lower claims will reduce premiums, and in extreme cases mean that the property remains insurable.
- For those who cannot obtain flooding insurance, adaptation measures represent a good investment, reducing the financial impact of a flooding event.

Flood damage
© Total Flood Solutions

Flood barriers to prevent inundation
© J. Schooling

Resilience measures are aimed at reducing the time and cost of recovering from a flood that has entered the home. Unlike resistance, the benefits from resilience measures are cumulative, so each improvement can be made individually, and gives a benefit by itself. Many of these adaptation measures can be installed when the householder is conducting planned maintenance or redecoration for little or no extra cost.

Typical resilience measures include:

Measure	Cost
Check the Environment Agency Flood Map	Free
Register with Environment Agency flood warning scheme	Free
Store valuables and paperwork upstairs	Free
Turn off gas, water and electricity mains	Free
Fit rising hinges so doors can be removed	L
Use dry-bags to protect soft furnishings	L
Use water-resistant paint for the lower portions of internal walls	L-M
Rewire, raising electrical points above flood level (with wiring drops from above)	M
Relocate meters and boiler above flood level	M
Relocate white goods on a plinth above flood level	M
Replace carpets with vinyl and ceramic tiles and/or rugs	M-H
Replace timber floors with solid concrete	H

Cost bands:

Free
L - Low (£1-£100)
M - Medium (£101 - £1000)
H - High (£1001+)

- Payback time is reduced if measures can be incorporated into planned or routine redecoration and refurbishment.
- Projects such as repositioning of boiler and white goods can be done at replacement.
- Residual costs will remain, but an effective package reduces insurance claims by 50 to 80 per cent (£20,000 to £32,000).[24]

External measures to reduce run off and allow floodwater to drain into the ground are difficult to quantify but form an important part of floodwater management strategies.

Examples include porous paving (Sustainable Drainage Systems, or SUDS) and green roofs. Rainwater harvesting measures may also be helpful if the collection tanks are empty at the time of the flood, acting as a storage volume, though this cannot be relied upon.

Measure	Cost
Use porous materials or open structures on driveways to enable water to drain into ground	H
Ensure that flood pathways on driveway enable drainage away from the home	H
Large scale rainwater harvesting system	H
Green roofs	H

Cost bands:

Free **L** - Low (£1-£100)

M - Medium (£101 - £1000)

H - High (£1001+)

The case study outlined later in this document describes typical flood resistance and resilience measures and payback periods for a semi-detached home.

Water stress

in the three regions

Water stress occurs when current demand for water is high in comparison with effective supply from precipitation and groundwater sources. The east, London and south east regions all contain large areas of water stress.

Climate change projections suggest that in the period to 2050 and beyond, the UK will experience wetter winters and drier summers. Overall precipitation may decrease by up to 15 per cent under the high emissions scenario, with considerable local and regional variation.

For the three regions, an overall decrease in total annual precipitation is projected. Both reduced summertime precipitation and the greater evaporation of surface moisture caused by hotter temperatures will result in lower water availability in summer. Winter precipitation is projected to increase, but there will be a corresponding increase in the number of intense rainfall events. Since water storage capacity is finite, these intense events do not necessarily lead to efficient capture of water.

As well as posing a problem for the human population, water stress will also compound over-abstraction issues in three regions area. Five hundred rivers, lakes, and wetlands in England are already at risk of damage from over-abstraction.[25] This may represent an incentive for saving water, as many consumers are more concerned about the environmental impact of the amount of water they use than its direct cost.[26]

An additional population of up to three million people are expected to live in the three regions by 2025.[27] Long-term per capita consumption is increasing due to changes in household size and increased installations of appliances such as 'power showers'. This has largely offset savings made by the introduction of more efficient appliances, for example WCs, under the Water Supply (Water Fittings) Regulations. This is demonstrated by figures from Thames Water showing average per capita use per day rising from 140 litres in 1980 to 153 litres in 1990 and to 163 litres in 2005. However, recent data shows that the rate of increase has slowed and in some areas consumption has started to decrease slightly.[28] Based on current rates of consumption, the increase in population will lead to increased domestic water demand in the three regions by 450 mega-litres per day.

The overall picture is therefore one of increasing population and demand for water, coupled with reduced rainfall putting pressure on water resources in an area already under water stress.

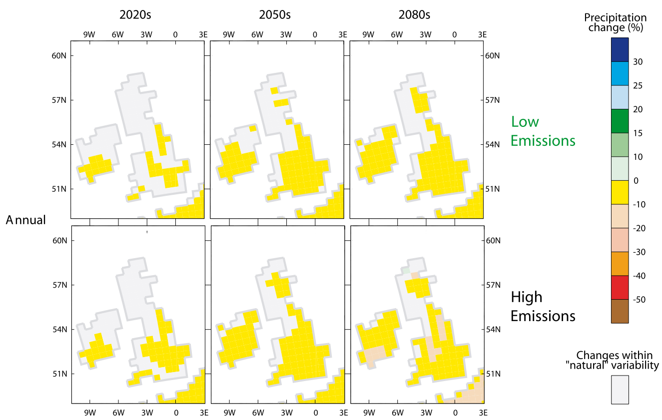


Figure 5 Mean annual precipitation under low and high emissions scenarios for 2020s, 2050s and 2080s.[29]

Water stress - the impacts of failure to adapt

If the demand for water outstrips supply, increasing levels of restrictions have to be imposed on customers to ensure that sufficient supply is maintained for essential needs. Hosepipe and sprinkler bans were imposed by seven water companies in the three regions during the summer of 2006, with a further three companies applying for drought permits.

Increasing supply to avoid interruption has a financial cost, requiring additional storage, pumps, and treatment infrastructure. This would add to the renewal and replacement capacity already planned.

Case studies on a typical house, flat and block in the three regions suggest that substantial savings can be made by retrofitting a simple package of measures in homes. For the case study house, savings of up to 200,000 litres of water per household per year could be achieved, whilst the flat case study (with two occupants) yielded savings of 72,000 litres per year.

Estimates by the Environment Agency[30] suggest in a typical household, retrofitting simple measures (such as those in the case studies) can result in savings of 14 per cent of average household consumption. If these measures could be extended across the 9,060,000 households in the three regions area, the water savings could be up to 410 mega-litres per day or 150,000 mega-litres per year. This is equivalent to the total domestic water use in three cities the size of Birmingham.

© K. Colquhoun

Although metered households will recoup the costs of investment in water-efficient products, the majority of domestic properties in the three regions are not metered. Additionally, even for metered homes, the current relatively low volumetric cost of water reduces the financial incentive to invest in water-efficient measures. However, reducing the consumption of hot water in the home represents a considerable opportunity for all householders to save money and reduce their carbon emissions. For the case study house, using a water-efficient shower resulted in water savings of 40,880 litres per year. At a hot water temperature of 40°C, this results in energy savings of around 1,430kWh per year for the household. Annual carbon savings amount to 600kg CO_2 and the potential financial saving is around £132 per year.

Average daily consumption of water is around 140 to 170 litres per person in the three regions, with one-third of this being used for personal bathing. With a shower or bath temperature of 40°C, a saving of 14 per cent in hot water consumption across the area would result in a reduction of 730,000 tonnes of CO_2 emissions per year,[31] equivalent to the emissions of around 300,000 cars.

There is also energy embedded in water purification, delivery and treatment. Carbon dioxide costs[32] for the supply of fresh water have been estimated at 0.289 tonnes per mega-litre, and those associated with the treatment of waste water are 0.406 tonnes per mega-litre. If the retrofitting scenario described above were implemented, achieving savings of 150,000 mega-litres per year of cold water, this would represent savings of 104,000 tonnes of carbon dioxide per year.

Water Stress - adaptation options and costs

The recent feasibility study on 'Water Neutrality for the Thames Gateway' showed that retrofitting existing homes in the Thames Gateway with water-saving appliances could save 23-47 per cent of the water required to maintain consumption at current levels while accommodating planned new developments.[33]

Adaptation measures for domestic buildings include a range of low-cost options that can be included as part of planned retrofit or refurbishment schemes. These measures are cumulative, and although the financial savings in terms of cold water cost for an individual item can be relatively small, they do result in rapid payback time. When energy savings from hot water saved are taken into account, financial savings can be significant. For example, the case studies suggest that switching to a low-flow shower head can save 22 litres of hot water per person per day, reducing energy consumption by 280kWh per year and so typically saving £26 per person.

This report concentrates on retrofitting measures for water conservation and efficiency, but the effects of behavioural change are also significant. For example, reducing an eight-minute shower by three minutes saves more water than replacing the standard shower head with a more water -efficient version. Many simple suggestions for saving water are available from sources such as Waterwise[34] and water company websites.

Some of the most effective measures are the least expensive. For example, in the case study house, fitting a low flow shower head saves as much water as fitting a new low flush toilet. Larger items, such as water-efficient white goods, have a longer payback time, but the price premium is not significant if they are replaced at the end of their operating lives.

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Water-saving device	Cost band	Potential water saved, per person per year (l)	Metered value of water saved, per year (£)	Water saving - elemental
Low flow shower or shower head	L-M	8176	16	Reducing flow from 10.8l/min to 8l/min
Ultra low flush toilet replacement	M	7884	15	Reducing from 9l to 4.5l per flush
Cistern displacement device	Free from water companies	Up to 5256	10	Reducing flush volume by up to 3l
Variable flush retrofit kit	L	Up to 7884	15	Reducing flush volume by up to 4.5l
Low flow bathroom taps (1.7l flow)	L	5087	10	reducing flow from 6.5l to 1.7l
Repair dripping taps	L	4745	9	saving 90l/week
Garden watering	L	5000	10	water garden using water from water butts. 5.3l/butt/day
Car washing	L	15643	31	Filling bucket from water butt eliminates use of 300l mains water/wash
Low flow kitchen tap adapter	L	7727	15	from 12 to 6l/min
Water-efficient dishwasher	M	1205	2	reducing from 25l/load to 14l/load
Water-efficient washing machine	M	4592	9	reducing from 80l/load to 43l/load

Table 4 Options, costs and savings for a range of water-saving measures, per capita.[35]

The case study on page 48 gives water savings and payback periods for a selection of retrofitting measures.

Cost bands:

Free

L - Low (£1-£100)

M - Medium (£101 - £1000)

H - High (£1001+)

Water stress - consumer response

More than 50 per cent of consumers would be prepared to pay to have their house retrofitted if it worked well and saved water.[36]

Some Water Facts and Figures

According to a WWF survey carried out in 2005, 80 per cent of consumers are willing to change their lifestyles to reduce environmental impact. While replacing inefficient water-using products with those that reduce wastage can reduce water consumption by up to a third, behavioural changes can also lead to significant savings.

- If every household in the UK switched from mains water to rainwater to water their gardens and wash their cars, this could save 30,000 million litres of water each summer. That would be enough water to fill Bewl Reservoir, the largest reservoir in Kent, reduced to only 36 per cent capacity in early 2006. (Source: Waterwise).
- If everyone in the UK turned off the tap while brushing their teeth, enough water would be saved to supply the whole of Scotland. (Source: Waterwise).
- If a tenth of British homes fixed just one dripping tap, enough water would be saved to supply the whole of Coventry or Cardiff. (Source: Waterwise).
- By taking a shower instead of a bath, one person can save about 35 litres of water per event and about 2kWh of energy, cutting his or her carbon footprint in total by about half a kilogram, or enough CO_2 to fill 18 party balloons! (Source: Waterwise/EST).
- If one person cut one minute off their shower time for a year, they would save 3,300 litres of water per year and 200kWh of energy. That's enough energy to heat water for over 6,000 cups of coffee! The person's reduced carbon footprint would be 50kg of CO_2 - enough to fill 1,800 party balloons or 12 red telephone boxes. (Source: Waterwise/EST).
- If a bowl was used for washing up instead of washing for five minutes under a running tap, a saving of about 30 litres per wash could be made.

Overheating

in the three regions

In the UK, summers have been becoming warmer over the last three decades, with nine of the ten warmest years in the last 350 years occurring since 1988.[37] The summers of 2003 and 2006 were particularly hot. In August 2003 temperatures in the UK exceeded 38°C (100°F) for the first time on record, with temperatures of 38.5°C recorded in the south east.

UKCIP02 projections for temperatures[38] in the three regions for the 2020s, 2050s and 2080s show a similar pattern across all three regions, and suggest that by 2050 we can expect to experience a summer like the hot summer of 2003 every other year. By the 2080s, the annual average daily temperature increases by 2 to 3°C under the low emissions scenario and by 4 to 5°C under the high emissions scenario. There will also be an increase in the frequency of summer days over 30°C.

In large urban areas, such as London, Peterborough and Southampton, night time temperatures are further elevated by the urban heat island effect, with buildings and infrastructure soaking up heat during the day and emitting it during the night.

The effect of overheating on buildings

There are several mechanisms which cause a building to gain heat:

- Internal heat gains these are caused by waste heat from equipment and lights, but can be limited by using low-energy equipment such as energy-saving light bulbs, and by turning equipment off when not in use. Over recent decades increasing use of electrical equipment has added to the heating of buildings.
- Heat gain through windows solar radiation passes through the window and hits the internal surfaces of the room, warming them up and causing them to heat up the air inside the room. Shading with shutters, awnings or blinds helps reduce this heat gain.
- Solar heat gain through warming of external surfaces roofs and walls tend to absorb heat, which gradually passes through to the internal surfaces and causes the inside spaces to warm up. Painting the external walls in light colours with reflective paint can help to minimise this effect.
- External air temperature when the outside temperature is higher than the inside temperature, open windows will admit hot air, causing the building to heat up.

In most UK dwellings the principal means of keeping cool in summer is ventilation, usually provided by opening windows. Historically, this method of cooling has worked adequately in the UK when it has been relatively cool outside. However, as outside temperatures rise it will become harder to provide cooling from ventilation alone. UKCIP projections are for more frequent summer days over 30°C. The UHI effect will exacerbate this in built-up areas, particularly in large towns and cities, by reducing the capacity to cool buildings at night.

By the 2050s, projected summer temperatures in the UK will be similar to those historically experienced in mediterranean climates, where buildings traditionally have small, shuttered windows on south and west facing walls, and are often painted white to reflect heat. Courtyards are also used to good effect, with vegetation and water features to temper the courtyard environment. Bars over windows on the outer façade allow windows to be left open without security concerns. These features allow mediterranean buildings to remain comfortable when the external temperature is high. Traditional UK building styles do not include these features, and so will be more prone to overheating.

Overheating - impacts of failure to adapt

Of the three key impacts covered in this study, it is overheating that has been directly responsible for the highest number of deaths in the three regions in recent history. Overheating is at its most dangerous when night time temperatures do not drop sufficiently for the body to cool down and recover, and when temperatures remain high for several days in a row. Currently, CIBSE Guide A[39] classifies overheating in dwellings as an exceedance of 28°C for one per cent of occupied hours in living areas, and an exceedance of 26°C for one per cent of occupied hours in bedrooms. It is recommended that temperatures exceeding 30°C are avoided.

In August 2003 an estimated 2,000 premature deaths occurred in the UK as a result of heat stress over the two-week period of the heatwave, with 600 of these deaths occurring in London alone. Emergency admissions to hospitals rose by six per cent in the same period. In France, where the heatwave was even more intense, 15,000 premature deaths are estimated to have occurred as a result of the extreme heat and at least 45,000[40] across Europe as a whole. No heatwave in global history has produced so many documented deaths.

Importantly, the deaths did not occur where temperatures were highest, but where they were most unusual. For example, the temperatures that caused so many deaths in Paris would not have been considered unusual in Cairo, Calcutta or Rome, but were 6°C over the August average for the city. A major factor is likely to have been the inability of buildings designed for historic climates to keep indoor temperatures within reasonable limits, increasing the physiological stress on vulnerable individuals.

The graph below shows how peaks in death rate closely followed temperature spikes over the period of the heatwave in the UK, in comparison to average death rates for that day in the preceding five years.

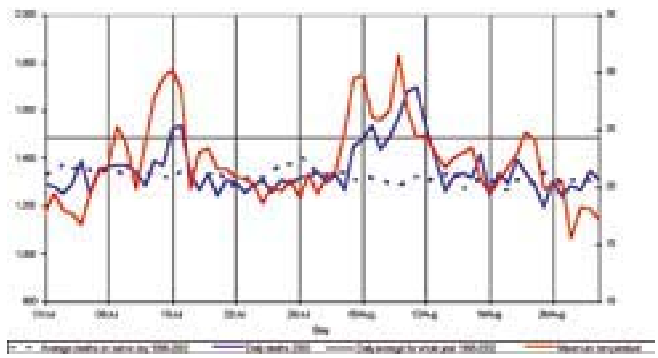


Figure 6 Daily deaths in England and Wales and maximum central England temperature, July and August 2003.[41] (Crown Copyright).

Additionally, overheating can cause discomfort and lead to lack of sleep and loss of productivity and alertness. Heatwaves also exacerbate water stress through increased bathing and discretionary use of water, for example for garden watering and in paddling pools.

Air conditioning may be viewed as a solution, but the disadvantages of mass take-up include increases in waste heat, noise, and ongoing energy costs. Not only does the increased energy use put strain on the electricity infrastructure, but it also leads to an increase in CO_2 emissions. If 50 per cent of homes in the three regions used air conditioning as in our case studies, this would result in additional CO_2 emissions of one million tonnes per year, equivalent to an additional 450,000 cars on the road.[42]

Overheating - adaptation options and costs

Whilst acknowledging that it is possible to cool buildings using air conditioning, this report concentrates on passive measures that allow householders to maintain comfortable temperatures while avoiding the environmental costs of air conditioning, such as carbon emissions, noise and waste heat.

Passive measures consist of reducing internal heat gains, enhancing natural ventilation and reducing solar gain through the windows and fabric of the building.

Insulation measures, such as installing loft and wall insulation and double glazing, can have a positive effect on keeping homes cool in the summer as well increasing winter heating efficiency. Increasing insulation helps prevent heat penetration from loft spaces and through walls. However, insulation also reduces heat loss through the building fabric at night. This effect can be compensated for by increasing ventilation at night and during cooler parts of the day. In the future it is likely that there will be increasingly demanding energy efficiency standards for new homes as well as continuing initiatives to encourage better take-up of insulation.

An effective package of passive measures to control overheating in the summer could include external awnings for south and west-facing windows, night purging using natural ventilation, ceiling fans in each room, and painting the external walls a light colour to increase their reflectivity. Costs for a typical unadapted house in the three regions would be approximately £16,000, but if winter warmth measures have already been installed, the cost of the adaptation package would be halved to around £8,000.

Additional measures include the use of trees to provide shade to the façades and even roof of the building. Deciduous trees are preferred, because they shed their leaves in winter allowing light into the building. Trees are best used on the west and east façades where sun angles are low. Overhangs and retractable shades which still allow winter sun access, can be used on south-facing aspects.

Disadvantages of using trees for shading are that it may take years for trees to grow to an effective height, and they should be located a suitable distance from the property in order to avoid contributing to subsidence problems.

Green roofs can reduce the amount of heat penetration through roofs and in this regard play a similar role to roof insulation. This is because they reduce the roof temperature through absorption of heat into their 'thermal mass' and because of evaporation of moisture. Different types of green roof are available and will have differing levels of thermal impact. Green roofs require professional surveys to establish which type is most suitable and whether the roof structure needs to be modified to bear the extra weight of the roof.

Adaptation measure and benefits	Limitations	Approx. costs
Switch off unused appliances, reducing internal heat gains and saving on running costs.		Free - L
Open windows at night to introduce cool air, providing natural ventilation.	Security may be an issue. Possible outdoor noise and poor air quality.	Free
Use ceiling or desk fans to create a local cooling effect.	Noise (but usually quieter than air conditioning).	L-M
Install a reflecting blind, ventilated by open window, to provide protection from the sun and reduce glare.	Security may be an issue.	L-M-H
Awning – protects rooms from the sun while allowing light, window ventilation and view.		H
Shutters - protect rooms from the sun and may increase security.	Reduced ability to ventilate via windows at the same time as shading.	L-M
Replace carpets with wooden floors or tiles to expose the cooling effect of the ground. Use rugs for colder periods.	Only relevant in ground floor rooms with solid floor construction.	H
Improve roof insulation standard to reduce heat penetration, particularly for slate roofs. This also reduces winter heat loss/energy bills.		L-M
Increase reflectivity through light-coloured painting/ coatings on walls and roof, preventing heat being absorbed into the fabric.	Alters appearance of façade.	L-M
Cavity wall insulation (where wall cavities are present) to reduce penetration of heat through walls.	In flood risk areas, use closed cell insulation.	M-H
Double glazing, with low-e coatings to reduce heat gain in summer and heat loss in winter.	Will increase overheating if ventilation provision is inadequate.	M-H
Install secondary double glazing behind existing glazing ('climate window') to create triple glazing, with external ventilation of outer cavity, that can greatly reduce solar heat gain provided inner pane remains closed.	Suitable only where window has deep set. Reduced ability to ventilate while also shading. May be lower cost and is more reversible than replacement window.	H

Cost bands:

Free **L** - Low (£1-£100)
M - Medium (£101 - £1000)
H - High (£1001+)

> There is a lack of knowledge within society around adaptation. We have a mitigation-focused mindset. We need to apply both in our lifestyles.

The urban heat island effect

The UKCIP02 climate change projections are based on a model that assumes a rural vegetated surface over the whole country. Therefore they do not take into account the urban land surface that modifies the climate of cities through the UHI effect. This effect is an elevation of urban temperature caused by the increased capacity of the urban land surface to absorb and trap heat.

This results in towns and cities remaining noticeably hotter than the surrounding countryside, particularly at night on calm, clear summer nights. The UHI can add 5-6°C to the night time temperatures experienced. During the summer heatwave of 2003, differences of up to 9°C between city and rural temperatures were measured in London.[43]

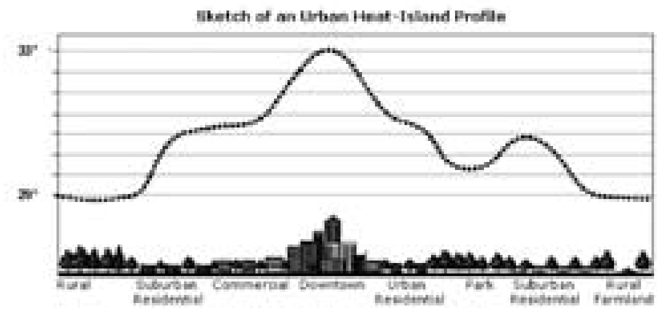


Figure 7 The temperature of urban areas with respect to the surrounding countryside.[43]

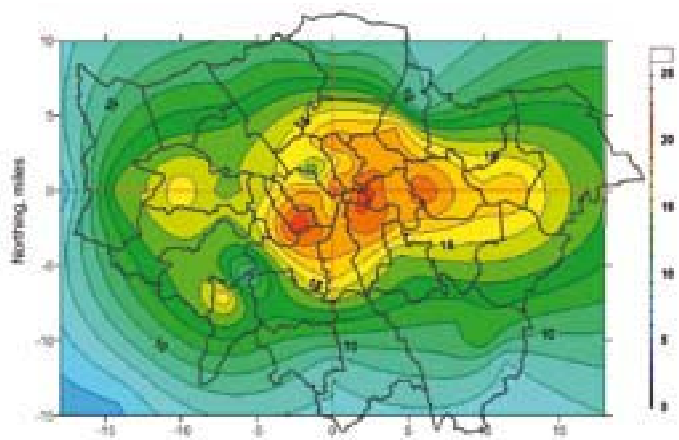


Figure 8 London's UHI, August 2003[43] shows how the temperature of the canopy layer heat island varies across London. The canopy layer 'map' was developed using air temperature measurements gathered in the 1999-2000 experiment described above. The scale shows the number of occasions that temperatures exceeded 19°C for 48 consecutive hours. The 'crosshairs' meet on the British Museum in the West End. It can be seen that high temperatures persist in central London, with 'hotspots' and 'coolspots' roughly corresponding with high-density areas and large greenspaces respectively. The canopy layer heat island is the air mass between ground level and average roof height.

The case study house

Three households were modelled in the course of this study: a 1930s house, a 1960s flat and a block of flats. All three case studies showed that solutions to adapt existing homes to reduce the impacts of flooding, water stress and overheating are currently available and that they are cost effective. The house case study is highlighted in this summary report. For further details of the flat and block case studies, please see the Case Study Technical Report.[34]

The house presented here is a typical example of houses throughout the three regions area. Chosen as an example of the prolific period of house building during the 1930s, the house is a three-bedroom semi-detached home with a paved front garden and a rear garden, but no basement.

We have assumed that a family of two adults and three children occupy the property, which has had little renovation. For overheating, we have modelled partial daytime occupation and full weekend and evening occupation. The property chosen has cavity walls, single glazing and minimal insulation.

A range of adaptation measures was chosen for each of the three key impacts - flooding, water stress, and overheating. In each case, measures were selected that could be applied to a range of properties, although it must be stressed that it is not possible to specify adaptation measures for any of the impacts without specific knowledge of the individual property. Where appropriate, costs have been given for professional installation of adaptation measures.

The property was assumed to be vulnerable to all three key impacts. For each of these impacts, adaptation measures have been considered which can play a part in reducing the vulnerability of a property to climate change. However, it is not possible to completely eliminate the risks associated with the most extreme weather events such as severe heatwaves, large-scale inundations, and long lasting drought.

It is important to note that this is a case study. All dwellings will vary in the extent to which they are at risk, and each property must be assessed individually.

Case study - adaptation for flooding

In this case study, two separate types of adaptation measures were considered. Resistance measures are designed to prevent water entering the property, while the aim of resilience measures is to reduce the time and cost of recovery from a flooding event.

Option	Total cost (including professional installation)	Maximum amount saved after a flood	How many floods pay back the investment?
Resistance package (for floods up to 0.9m)	£13,750	£23,100/ event	0.60 events
Resilience measures	£4,495	£4,270/ event	1.05 events

It is clear that whether resistance or resilience measures are installed, the investment pays back in a single flood.

The resistance package is 'all or nothing' (every entrance to the home must be blocked) and requires a large single investment by the householder.

Door Dam
©Total Flood Solutions 2007

Smart Airbricks
© Eco-coverage 2007

In contrast, each resilience measure independently reduces the cost of recovery from a flood, and the savings are additive, so the householder can make investments and install adaptation measures over a period of time and still gain the benefit from those measures completed in the event of a flood. With measures that rely on placing valuable items above the level of flooding, savings will only be made if the expected maximum water level is not exceeded, and if the householder has sufficient warning to allow preparations to be made.

Resistance measures chosen were:

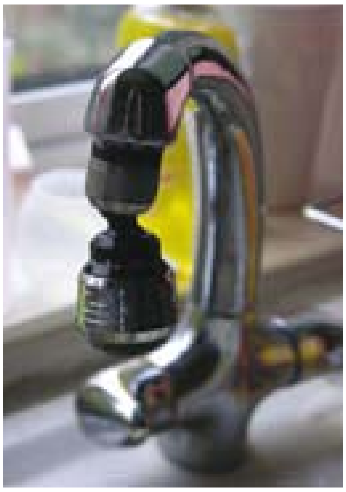
- non-return valves on main drains
- temporary door guards
- raised door thresholds (additional work may be required to maintain disabled access)
- waterproof membrane from 0.6m below ground to 1m above
- reusable air brick covers/SMART air brick replacements
- sealing of gaps around pipes, cables, windows and door frames.

Resilience measures chosen for the case study are given below, with sample costs:

- raise boiler above flood level (£745)
- raise electrical points/meter (£230)
- replace chipboard flooring with solid timber (£2,665)
- internal doors - fit rising hinges (£30 - DIY)
- dry-bags (£150 - DIY)
- place large items like the fridge, washing machine and oven on a concrete plinth (£675).

Case study - adaptation for water stress

For this case study we assumed that the house had not been renovated for about 20 years, so the bathroom and kitchen fittings do not meet current standards for water efficiency. The house was assumed to be metered so that payback times could be assessed in terms of cost savings on water bills. The benefits from water efficiency measures are cumulative, so this package would not have to be installed simultaneously, and the householder could choose to update different elements separately. In each case, figures are given for the full cost of replacement, including professional fitting.



Water saving tap fitting
© K. Colquhoun

Water saving showerhead
© Waterwise

Dual flush toilet
© Waterwise

Water efficient dishwasher
© Waterwise

Waterbutt
© K. Colquhoun

Waterbutt
© www.greenbuildingstore.co.uk

The adaptation measures chosen for the house were:

Item	Change made	**Potential annual water saving for family of five** (litres)	**Sample cost** (including professional fitting)	**Typical payback time for a metered home** (item cost/ water cost saved)
Toilet	Replace old toilet (9l cistern) with new 4.5l toilet	41,000	£290	Four years
Shower	Replace old gravity-fed shower with new, lower flow electric shower	39,000 (assuming eight-minute showers)	£140	Two years based on cold water costs - one year if you take into account the energy saved on water heating
Bathroom taps	Replace old models with new monoblock taps	Up to 25,000	£80	18 months
Washing machine	Replace with water-efficient version	23,000	£380 (similar to standard machine)	No additional cost if you are replacing a worn-out machine
Dish-washer	Replace with water-efficient version	6,000	£380 (similar to standard machine)	No additional cost if you are replacing a worn-out machine
Kitchen taps	Fit a low-flow adapter	Up to 39,000 (depending on tap usage)	£20 (DIY)	As little as four months
Garden watering and car washing	Install and use water butts	Up to 20,000	£40 each (DIY)	One year (if water used for both garden watering and car washing)

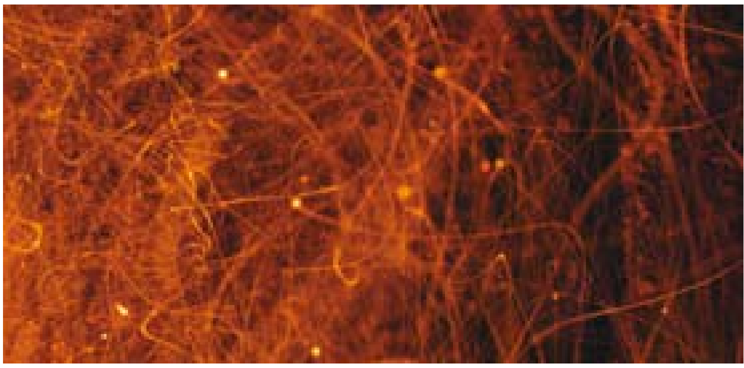
Table 5 Water savings in the adapted house.

The low-flow shower also saves the household 1400kWh energy per annum. It also cuts the fuel bill by £133 and reduces the household's carbon footprint by 600kg CO_2 because of hot water savings.

Case study - adaptation for overheating

Modelling of the case study house for July temperatures in both the bedroom and the living room showed that in both the current climate (as represented by the 1989 design year) and the projected climate for the 2050s, the unadapted house would experience overheating. In the climate of the 2050s the living room would be above comfort temperature for 30 per cent of occupied hours, and the bedroom for 6 per cent of occupied hours. By the 2050s, overheating would be experienced in 50 per cent of occupied hours in the living room, and 20 per cent in the bedroom.

Internal Shutters



The following combination of adaptation measures were modelled for the house, see the table below.

Although costs appear high, the top three items on the list have a substantial effect and are relatively low cost. Increasing ventilation rates, particularly when it is cooler at night, was found to be the single most effective measure. The additional measures, while at a higher cost, can be included as part of planned redecoration, upgrades and maintenance of the property.

Currently, CIBSE Guide A classifies overheating in dwellings as an exceedance of 28°C for one per cent of occupied hours in living areas, and an exceedance of 26°C for one per cent of occupied hours in bedrooms.

Measure	**Cost** (professional installation unless stated)
Measures which aid overheating only	
• External solar control: awnings on all south/west windows.	£1,700
• Natural ventilation through windows.	No cost for existing windows
• Enhance air movement: ceiling fans (DIY installation).	£545
• Floor coverings: replace carpets with wooden floor or tiles on ground floor.	£2,100
• Façade upgrade: paint walls to increase reflectivity.	£3,750
Total cost of measures for overheating only	**£8,095**
Additional cost of winter insulation measures	
• Roof: improve roof insulation standard.	£2,200
• Façade upgrade: cavity insulation where cavities are present.	£1,100
• Fenestration upgrade: replace single glazing with double glazing, with low-e coatings.	£5,000
GRAND TOTAL	**£16,395**

Retrofitting the recommended package of adaptations causes a dramatic reduction in the number of hours in which the rooms exceed overheating and comfort temperatures, as shown in Figure 9. With the measures installed, the overheating temperature is never exceeded in the 1989 design summer year. By 2050, in July the overheating temperature will be exceeded in only 1.1 per cent of occupied hours in the bedroom and 2.2 per cent of occupied hours in the living room.

Figure 10 shows the cooling degree hours for the living room and bedroom for the month of July when temperatures are hottest. Each graph shows the case study house with and without the selected adaptation improvements, in a current July and a projected 2050's summer. The bottom two graphs illustrate the air conditioning power (kWh on the right hand axes) required to cool these rooms in an unadapted house to the CIBSE comfort temperatures (25°C in the living room and 23°C in the bedroom). Cooling degree hours are used to measure the extent to which a room overheats. This is calculated over the month of July as the number of degrees by which the comfort temperature is exceeded for each hour the house is occupied. It is clear from Figure 10 that adapting homes for overheating has a significant effect on the degree of discomfort. The research showed that non-energy intensive adaptation options potentially eliminates the need for air-conditioning, or significantly reduces the amount of energy used to cool the house.

© ARUP

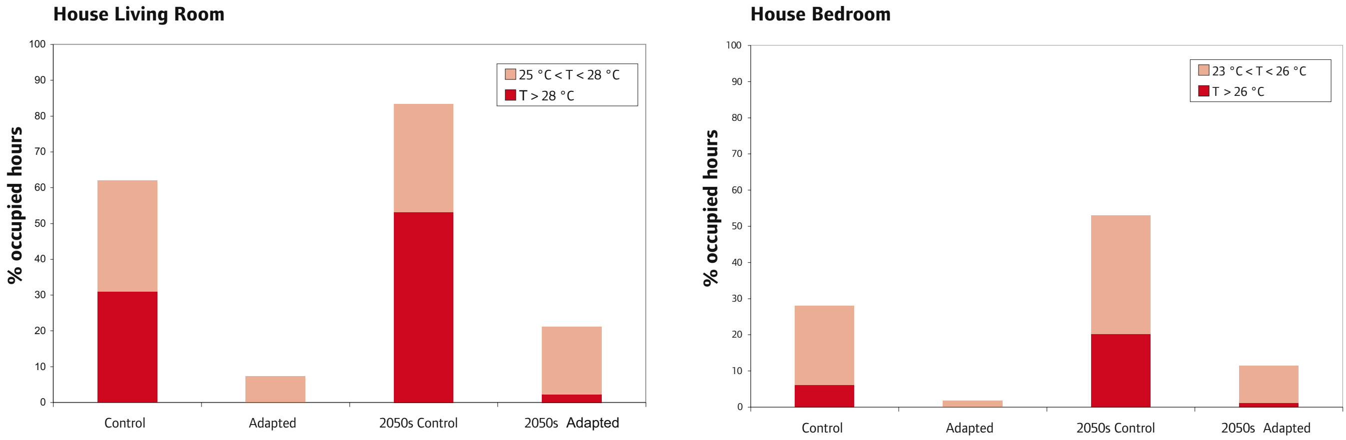


Figure 9 Temperatures in the unadapted and adapted house for July 1989 and 2050.

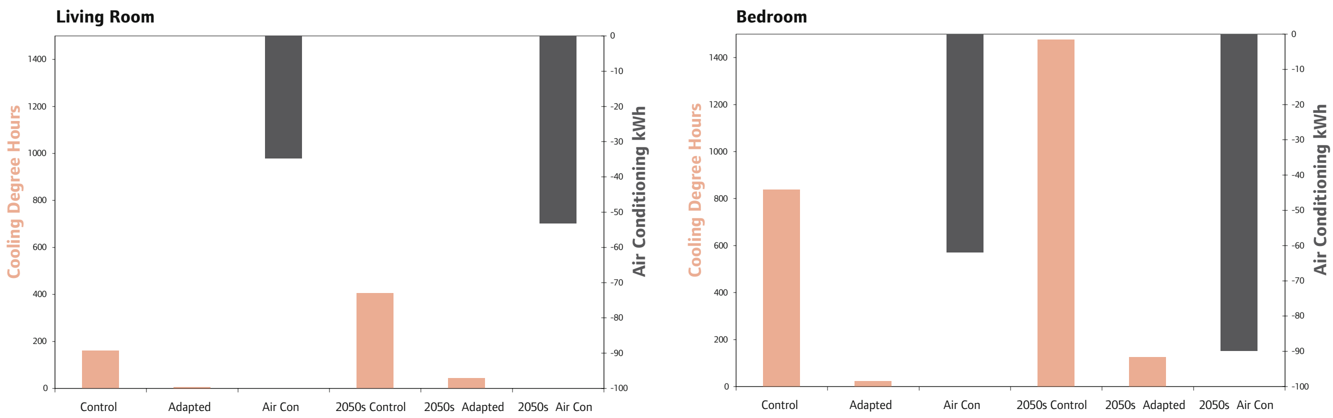


Figure 10 Cooling degree hours for the month of July. The right hand axes show the total power consumption of an air conditioning system (in kWh) used to control overheating in the unadapted home.

‘It's not as simple as introducing new technology. We thought, as solar thermal came in, that it would get cheaper. But demand in the last few years has outstripped the supply of fitters.’

Enabling adaptation

An important distinction between mitigating and adapting to climate change is that adaptation needs to be addressed locally while mitigation requires both local and global action to reduce greenhouse gas emissions. The choice of appropriate retrofit adaptation measures will vary according to location, the local climate (current and future) and the building type involved.

As with mitigation, much of the focus for adaptation of housing stock for the impacts of climate change has been concentrated on new build. Incorporating adaptation into new build can be guided by local bodies (planning departments and building control), as well as through planning and building regulations set by the Department of Communities and Local Government. However for existing homes, the impetus to, and responsibility for adapting buildings comes largely from the individual householder or landlord. It is not mandatory, nor is it under the control of any government department or agency.

A householder's willingness to adapt depends on a number of issues, including:

- awareness of a need for adaptation
- availability of information on appropriate adaptation measures, their costs and benefits
- availability of funds to make the changes, which in turn is affected by tenure
- local, skilled installers willing to undertake the work
- availability of technologies.

In practice, a wide range of unconnected actors are involved in influencing and supporting householders through the process of ensuring that their homes are appropriate for our changing climate. Adaptation in an individual case may be dependent on the timely intervention of a combination of these actors, with varying motivations for involvement and influence over the householder. Examples include installers and suppliers, housing market institutions, utilities and NGOs.

Water companies, and NGOs such as Waterwise, have been active and effective in encouraging water efficiency, and programmes by (among others) DEFRA and Norwich Union have created demonstration homes in areas that suffer frequently from flooding. Guidance on adaptation for overheating risk includes the UKCIP report 'Beating the Heat'. However, these responses are fragmented by impact, sector and location.

The coordinating role of central government is critical. Each of the parties influencing the householder must be persuaded to work in concert, to create a framework in which householders are enabled to adapt their homes for flooding, water stress and overheating.

> The Code for Sustainable Homes is a step in the right direction for new build, but we also need to improve how we use our existing homes - how people behave is just as important as the devices we fit into our houses.

© Arup

The framework in which householders will act

Householders cannot be treated as a homogenous group. The largest single group in the three regions are owner-occupiers, and this is the group with the greatest incentive and capacity to act. However, it must not be assumed that all are willing or able to invest in their homes, even if it makes financial sense to do so.

For landlords, the financial incentive to adapt their homes is weaker, with the main beneficiaries of reduced water and energy bills being the tenants. Adaptation may make properties more attractive to tenants, and so allow a premium price to be charged, but this will have little effect in a buoyant market. For flooding, there is a financial incentive for landlords to install measures that protect the fabric of the building, but not necessarily those that protect the tenant's property.

For tenants, the incentive to adapt a property is limited by the need to obtain permission, and the lack of long-term commitment to a property.

If householders and landlords are to be enabled to act, they need to be given a simple, clear message: the climate is changing, their properties may perform poorly in the in the face of flooding, water stress and overheating, and there are financial, environmental and health benefits to making proactive adaptations.

A framework is needed to enable householders to act. Policy makers and delivery agencies need to set up this framework and work with appropriate agencies to raise householder awareness. The message should be approached sequentially:

- Knowledge and awareness
  People need to be made aware of local impacts of climate change including overheating, water scarcity and flooding, the timescales on which events may occur and factors that influence vulnerability to these impacts. People also need to be aware that climate change is not something just for the future. The climate is already changing, increasing the likelihood of 'extreme' events occurring.
- Ability to assess personal risk
  People need to be able to assess the risk to their property either through simple assessment tools or expert advice, or a combination of both. Proper assessment will enable appropriate adaptation.

- **Positive image association**
  Climate change adaptation should be associated with positive lifestyle choices, enhancing quality of life and/or social status.
- **Access to advice and guidance**
  Once an individual has taken the decision to adapt their property, they need to be able to access the appropriate support to transform intention into action. This includes being able to find trained installers to fit appropriate adaptation measures.
- **Ability to assess economic benefit of adaptation**
  If financial costs are a key factor in the decision-making process, the ability to assess the long-term returns on investment will be important in enabling decisions to be taken. Where adaptation increases the value of a property, or reduces insurance premiums, this must be apparent.

Effective promotion of these adaptation messages also means ensuring that they become an integral part of both the mitigation agenda and a quality of life agenda. Although there are economic benefits to adaptation, these will not apply to all properties or individuals, so it remains important to stress the wider social and environmental benefits of adaptation.

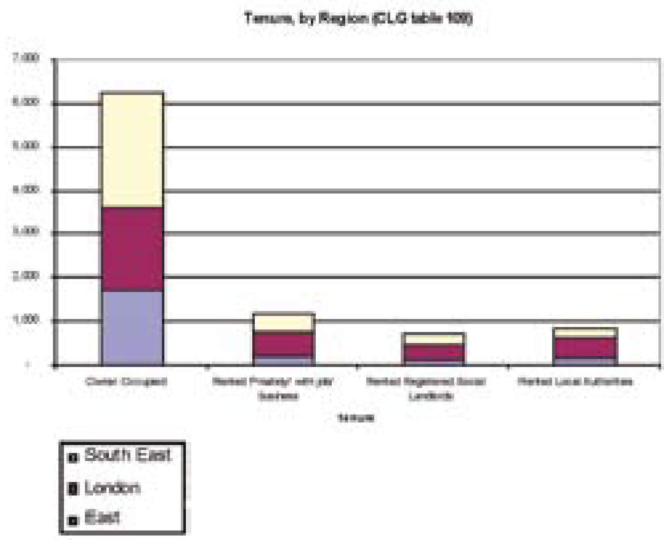


Figure 11 Tenure by region for the three regions area.[45]

How does tenure affect the adaptation of existing homes?

Tenure does not affect the impacts that a particular building may suffer, but it does affect the householder's response to an impact. The tenure types considered in this study are privately rented, rented from social landlord or local authority and owner-occupied.

Free or low-cost options are within the scope of all householders, but the decision to invest in more expensive adaptation options may depend on the likely financial return from making changes. Tenancy affects householders' willingness and ability to act, for example because of the need for negotiation with landlords or other freehold partners.

Within the three regions, tenure is dominated by owner-occupied homes. These make up 69 per cent of the housing stock.[45] Privately rented homes make up 13 per cent, with registered social landlords at 8 per cent and local authorities at 10 per cent. In each case, the east and south east regions are similar to each other, with London having fewer owner-occupiers (59 per cent) and more rented accommodation, from both private and social landlords. Social landlords are in many ways in the best position to oversee adaptations, having control over estates and blocks, access to capital, and incentives to maintain the quality of the accommodation.

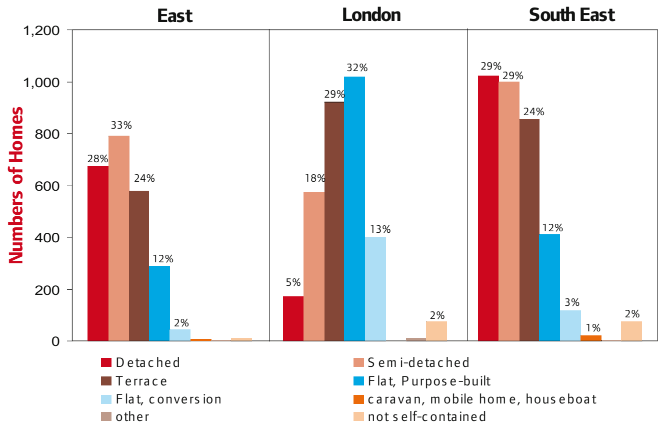


Figure 12 Types of dwellings in the three regions.[46]

Building types

As well as age and tenancy, building type is also a factor that affects the impact that climate will have on a building, and the types of adaptation that may be possible or practicable. Those that involve structural change to the building are easier when the fabric of the building is the responsibility of a single party - for example, a detached house, or a block controlled by a housing association or social landlord. For flats within blocks, whether purpose built or converted, negotiation may be required with the freeholder or freehold partners to make alterations. In addition, the conditions of the leasehold or tenancy of blocks may preclude alterations to the fabric of the building.

What prevents action?

Although there is a high level of consensus within the climate change community of the causes and implications of climate change, public understanding is at a very different level. The public are aware of climate change as a concept, (in a recent poll, 97 per cent of respondents had heard of climate change)[47] but the complexity of the subject means that it is only understood at a superficial level. Crucially, there is a low awareness of the link between global climate change and local impacts.

The changing nature of flood, drought and overheating events are making our buildings inappropriate for our current and future climate. Although cost-effective adaptations are available that can make our homes comfortable and robust in the face of these impacts, there are significant barriers to the widespread uptake of adaptation measures.

For all impacts, barriers include:

- The perceived complexity of climate change and its impacts, combined with a tendency to act on the basis of experience, rather than a future hypothetical event. This reduces the householder's ability to assess risk and urgency for action.
- Lack of awareness of appropriate adaptation options, access to trusted impartial technical advice, or information about the cost benefit of measures, combined with a lack of contractors offering services in adaptation.
- Extensive variation in the construction, age and condition of housing stock in the three regions. This means that a high level of individual assessment is necessary to select appropriate adaptation and avoid potential negative consequences.

In addition, each of the three key impacts has its own complications.

Flooding:

- Flooding is an unpredictable event, making it difficult for householders to prioritise investment in flood resilience and resistance measures.
- Establishing the flood risk of a property from a range of sources is complex. The Environment Agency flood map shows the risks from river and coastal floods, but they do not include other sources such as flash sewer flooding and groundwater flooding.
- Appropriate flooding adaptation measures, particularly for resistance, must be tailored to specific properties, since costs and limitations of measures are strongly dependent on the construction and location of the building.

Water stress:

- Water stress impacts are regional, hence widespread uptake is necessary for the situation to improve significantly. However, a householder may see individual benefit in terms of reduced water and energy bills.
- Low levels of metering penetration reduce the financial incentive to save water.
- here is low awareness that being efficient with hot water brings an energy cost saving (and reduces CO_2 emissions).
- Price of water is low and so has limited impact on behavioural change.

Overheating:

- There is low awareness of domestic overheating as an impact of climate change.
- For some properties, particularly in the UHI, it may not be possible to achieve comfortable temperatures using passive measures alone. Security fears may also prevent people leaving windows open at night.
- In order to achieve comfortable temperatures in hot summers, adaptation measures must be planned and installed in advance. In contrast, air conditioning units are readily available, inexpensive, and can be easily installed. Air conditioning has negative consequences in terms of noise, waste heat and carbon emissions.

An example of a successful campaign

Thames Water has been actively promoting water conservation since 1996. One of the largest efforts to date has been the 2006 drought communications campaign, which was partly conducted in collaboration with other water companies and local and regional authorities.

The coordinated campaign resulted in a record response from the public. Reductions in distribution input suggest that demand fell by an average of 84.1 megalitres/day (3.1 per cent) during 2006/07, with the largest decrease being seen during a week in July, when demand fell by 8.6 per cent in London and 14.3 per cent in the Thames Valley.

The campaign included the following:

- Letters sent to 3.3 million households about the drought, leakage and hosepipe ban. 'Beat the drought' leaflets were sent out to 1.2 million customers with their bills.
- A drought homepage on the Thames Water website providing information about the water resource situation, water use restrictions, and links to useful sites.
- Participation in the 'Beat the drought' campaign with other water companies in the south east. (www.beatthedrought.com).
- Thames Water 'Droughtbusters' toured the region to promote water conservation and efficiency - volunteers dressed up as recognisable water-using appliances to bring the message to life.
- A drought speaker programme gave talks to groups from schools, rotary clubs, environmental groups, neighbourhood watch and housing associations.
- Thameswater co-sponsored the water-efficient 'Sunshine Garden' at the Hampton Court Flower Show in July, talking to visitors about water-saving measures for the garden.
- A promotional campaign in 41 Homebase stores provided 100,000 water-efficiency packs. This was promoted through regional and local press and radio.
- A 'Help us to beat the drought' Water Wise Assembly pack was produced for schools. Over 2,500 packs were requested across the Thames Water region.
- An integrated programme of advertising in newspapers, public washrooms, radio, roadside billboards, buses, online, and product placements on TV reached an estimated 99 per cent of customers 50 times.

The total cost to Thames Water of the communications campaign was £4.5 million.

Essential participants for widespread uptake of adaptation measures

The responsibility for making adaptations to an existing home rests with the householder, but a wide range of actors play critical roles in educating, encouraging and enabling householders to make appropriate choices.

Each actor has a different motivation according to their relationship with the householder, and needs a targeted message to persuade householders to engage in the process.

Individuals and institutions with a critical role to play in enabling adaptation include:

central, regional and local government	government bodies at all levels set the frameworks in which others will act. Adaptation needs to be recognised as a core part of the climate change agenda and other agendas (eg housing), and incorporated into existing policy as appropriate.
installers, suppliers and professional institutions	these are fundamental to enabling adaptation to be implemented, as they provide information to householders as well as the skilled services needed to install adaptation products.
mortgage companies	these have the potential to influence owner-occupiers and landlords both at the time of purchase and during their ongoing relationship, as they have a long-term relationship with the householders and are equity holders.
insurance companies	these have influence over homeowners, though contact is usually limited to annual renewal. They do have an opportunity to influence homeowners during a claims process, particularly for flood resilience and resistance.
Home Information Pack (HIP) assessors, surveyors and architects	these all have access to people's homes and are therefore ideally placed to provide advice on adaptation. There is a particular synergy for HIP assessors with the energy efficiency agenda.
NGOs	a number of NGOs are already working with vulnerable groups and are in an ideal position to promote adaptation.
schools and universities	it is important to reach future tenants and householders and give them the knowledge and aspirations to ensure that this issue is addressed. Students form the generation that can expect to live through the more extreme projections of climate, where the older generation may feel 'This doesn't apply to me; I'll be gone by then anyway'.
homeowners	private homeowners make up the largest component of the housing sector. By purchasing the more efficient water saving items, the non-energy intensive cooling technology and the flood resilient items, homeowners can drive market forces and deliver sustainability improvements.

Actions for policy makers

In recognition that the majority of adaptation will be carried out in practice by an unconnected array of actors, the most important single role for central government at all levels, is coordinating, encouraging and enabling the activities of those who will deliver adaptation to individual householders.

Integrating and mainstreaming climate change adaptation into all areas of public policy to drive adaptation in existing homes is one of the most important actions for government. This might include embedding adaptation into the new Decent Homes programme post-2010 and linking adaptation to mitigation where relevant.

This process can be approached using the model outlined in 'Securing the future - delivering UK sustainable development strategy',[49] which focuses on the 4 'E's - Enable, Encourage, Engage, and Exemplify.

Enable make it easier	Provide information about the local impacts of global climate change, and clear portals for householders to access information about the costs and implications of adaptation measures. Work to incorporate the adaptation agenda into training for those who are responsible for the practical installation of adaptation measures such as social registered landlords and installers. Provide a leadership role in ensuring that all aspects of accomplishing retrofitting are eased for the householder.
Encourage give the right signals	Ensure that the taxation system encourages adaptation measures, for example by reducing VAT on products which form part of a suite of adaptation measures, such as flood barriers and water-efficient products.
Engage get people involved	Incorporate adaptation into campaigns and programmes that people are already involved in, such as the Warm Front insulation programme, the 'DIY planet repairs' campaign and the Green Homes initiative.
Exemplify government takes the lead	As well as encouraging others to adapt, the use of adaptation measures on public buildings demonstrates that adaptation measures are available, attractive and work at least as well as non-adaptive alternatives. In addition, procuring adaptation measures for public buildings will play a valuable market transformation role.

Actions required from the different constituencies

Professional installers, fitters, suppliers and retailers

Professional institutions have an important role to play in informing and training their members as to the importance of adaptation technologies, the appropriateness of different measures, and the nature of the adaptation market. The inclusion in professional curricula of the costs and benefits of adaptation measures is an essential step in ensuring effective uptake. Without acceptance by the professional installers, widespread uptake will be difficult to achieve. Additionally, retailers are a source of information at the point of sale.

Recommendations:

- Develop the adaptation skill set by incorporating the installation, maintenance and cost/benefit of adaptation measures into professional training and CPD for fitters and installers.
- Promote education within institutions about the local impacts of climate change, the need for adaptation, and the availability of grants and other incentives. Organisations that should be engaged with include CIBSE, BISRIA, IPHE and CORGI.
- Introduce a robust water-efficiency labelling scheme similar to the energy-efficiency labelling scheme.

Collaboration with existing campaigns and programmes

There is a very real risk that trying to engage the public with the adaptation issue could be counterproductive, with an emphasis on inevitable changes as a result of previous emissions reducing the effectiveness of campaigns to persuade people to reduce emissions. A more effective approach could be to ensure that adaptation and mitigation campaigns are integrated, rather than approached separately.

In addition, the adaptation agenda should collaborate with 'quality of life' initiatives, such as the fuel poverty initiatives aiming to increase the comfort of vulnerable groups in the winter. In some cases, there are clear synergies between agendas - for example, any measures to use hot water more efficiently (such as low-flow showers) will also result in a substantial energy saving. Examples include the 'Warm front' programme, installing insulation in targeted homes.

Recommendations:

- Incorporate adaptation messages and information into mitigation campaigns, such as 'DIY Planet Repairs' and Green Homes.
- Incorporate adaptation into the successor to the Decent Homes programme (due to end in 2010).

Collaboration with existing groups

Water stress and flooding both affect the three regions areas independently of climate change, and so opportunities for collaboration between stakeholders already exist. A good example of this is DEFRA's Water Saving Group, which brings together key players to look at opportunities to manage water demand. However, overheating is the least well understood of the three key impacts, and does not have the benefit of existing interest groups.

Recommendations:

- Establish a similar group to address the impact of overheating.

Funding, grants and incentives

Cost represents one of the most significant barriers to adaptation for householders, although this barrier is compounded by others such as inertia and uncertainty. For tenants, there is little incentive to make adaptations requiring alterations to the fabric of the building, since they will only be of benefit during the course of their tenancy. Subsidised insulation schemes are available via energy utilities as part of their Energy Efficiency Commitment, but the benefits of these are given in terms of winter saving. The potential benefits of insulation for keeping buildings cool during the summer receive little attention, and insulation may be erroneously considered by householders to exacerbate the problem.

Recommendations:

- Incorporate adaptation measures into existing mitigation incentive schemes, using existing organisations such as the Energy Savings Trust.
- Reduce VAT on adaptation measures such low-flow showers, flood barriers and shutters.

Utilities and manufacturers

Water companies have a long history of work on water stress, with the success of recent campaigns building on those that have taken place over the last three decades. Utility companies have an ongoing relationship with their customers, and are in an ideal position to give them information about the personal and community implications of their water and energy consumption. Working with manufacturers to encourage use of water labels (as promoted by the Bathroom Manufacturers Association) will help consumers make more efficient choices, and these could be supported by utility companies.

Recommendations:

- Encourage the use of water and energy bills to give customers feedback on their consumption in comparison to their community and to previous billing periods.
- Support the introduction of a robust water efficiency rating label, similar to the energy efficiency rating labels.
- Ensure that procurement in public buildings demonstrates best practice for adaptation.

Mortgage companies

Mortgage companies require insurance indemnity, and may be able to work with the insurance industry to encourage homeowners to retrofit appropriate adaptations. Of households in the three regions, 69 per cent are owner-occupied, and of these, 57 per cent are buying with a mortgage.

Recommendations:

- Encourage mortgage companies to release equity from the property allowing the homeowner to implement adaptations.

Home Information Pack (HIP) assessors

In common with surveyors, estate agents and architects, HIP assessors are in a strong position to influence householders when they are moving home - an ideal opportunity to promote retrofitting.

Recommendations:

- Flood risk information, available from the Environment Agency, should be included in HIPs.
- Adaptation measures, as well as energy efficiency measures, could be included in HIPs.

Insurance companies

Insurance companies, and the Association of British Insurers, are already active in promoting measures to reduce the damage caused by flooding, and to inform householders of the options available to them. However, adoption of flood resistant and resilient measures remains low. For example, in a recent survey flood victims were interviewed once their properties had been restored, and asked what plans they had for adapting their homes against future flooding. Eighty per cent had no plans to make any adaptations to their homes.[50] Where householders choose not to insure - or cannot do so - adaptation can reduce the financial risk.

Recommendations:

- Insurance companies should continue to work together with the ABI to promote flood-resilient repair to householders who have already made flood insurance claims.

> "We need to work together and show the public what an adapted house looks like, how much it will cost, and what the long-term benefits will be."

Total Flood Solutions

Directory

further information and resourses

General

The Intergovernmental Panel on Climate Change (IPCC) has produced four major assessment reports since 1992 covering climate science, impacts and adaptation, and mitigation of climate change. The latest report, AR4, was published in 2007.
www.ipcc.ch/

The UK Climate Impact Programme (UKCIP) coordinates research on how climate change will have an impact in the UK at regional and national levels.
www.ukcip.org.uk/default.asp

Climate Challenge is a government programme for communication projects to improve public attitudes about climate change.
www.climatechallenge.gov.uk/in dex.html

DIY Planet Repairs provides practical advice and useful information on reducing your carbon emissions.
www.london.gov.uk/diy/

Climate change information from the BBC Weather Centre.
www.bbc.co.uk/climate

Stern Review: The Economics of Climate Change. UK Government's analysis of climate change effects on the global economy.
http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm

Flooding

Environment Agency Flood Map. Identifies if your home or business is in a tidal or fluvial flood zone using post-code locations.
www.environment-agency.gov.uk/subjects/flood/826674/829803/?version=1&lang=_e

The Norwich Union guide to flood-resilient homes including a flood simulator and flooding support pages
www.floodresilienthome.co.uk/

The Flows projects show an example of a home converted for flood resilience.
flows.wb.tu-harburg.de/index.php?id=471

The National Flood Forum's blue pages - a directory of products and services to improve your home's flood resilience.
www.floodforum.org.uk/flood_forum/NFF_BluePages_Master.pdf

What's My Flood Risk - provides a flood risk rating for properties, flooding probability and likely insurance position.
www.whatsmyfloodrisk.com

Flood Protection Association - provides information on flood alleviation systems suppliers, installers and flood management advice.
www.floodprotectionassoc.co.uk

CIRIA flooding guide - advice on the repair and restoration of buildings following a flood.
www.ciria.org/flooding/

Water

Interpave - Guidance for homeowners on responsible rainwater management, permeable paving and SuDS.
www.paving.org.uk/permeable.php

Waterwise - independent NGO focused on reducing water consumption in the UK. It provides advice on water efficiency and its website includes database of water-efficient appliances.
www.waterwise.org.uk/

Environment Agency - Water Resources website provides advice on how to save water at home and at work.
www.environment-agency.gov.uk/savewater

Many water companies have regular special offers on water-efficient devices such as water butts. Find your local water company from:
www.water.org.uk/home/resources-and-links/links/water-operators

Conserving Water in Buildings' information source for water conservation.
http://www.environment-agency.gov.uk/commondata/acrobat/geho1107bnjree_1934318.pdf

Overheating

Energy Saving Trust - contains a database of grants available for insulation, and other energy efficiency measures.
www.energysavingtrust.org.uk/proxy/view/full/2019/grantsandofferssearch

Construction Resources - ecological builder's merchant, selling insulation made from renewable resources.
www.constructionresources.com/

An Australian guide to using passive measures to for keeping your home cool.
www.greenhouse.gov.au/yourhome/technical/fs10.htm

Beating the Heat (UKCIP) - looks at how buildings performance needs to provide thermal comfort using passive and mechanical cooling.
http://www.ukcip.org.uk/resources/publications/pub_dets.asp?ID=69

CIBSE TM36 'The indoor environment of buildings: impacts and adaptation'. Standards and guidance on indoor thermal comfort and overheating.
www.cibse.org

The Energy Efficiency and Renewable Energy Clearinghouse (EREC).
www.nrel.gov/docs/legosti/old/15771.pdf

References

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2 IPCC (2007) Fourth Assessment Report. http://www.ipcc.ch/

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Supporting Organisations

GOVERNMENT OFFICE FOR LONDON	Government Office for London http://www.gos.gov.uk/gol
LONDON climate change PARTNERSHIP	London Climate Change Partnership http://www.london.gov.uk/climatechangepartnership
South East Climate Change Partnership	South East Climate Change Partnership http://www.climatesoutheast.org.uk
Sustainable Development Round Table for the East of England	The Sustainable Development Round Table for the East of England http://www.sustainabilityeast.org.uk
Environment Agency	Environment Agency http://www.environment-agency.gov.uk
Thames Water	Thames Water http://www.thameswater.co.uk
UK Climate Impacts Programme	United Kingdom Climate Impacts Programme http://www.ukcip.org.uk
LONDON DEVELOPMENT AGENCY	London Development Agency http://www.lda.gov.uk
MAYOR OF LONDON	Greater London Authority http://www.london.gov.uk
ARUP	ARUP http://www.arup.com