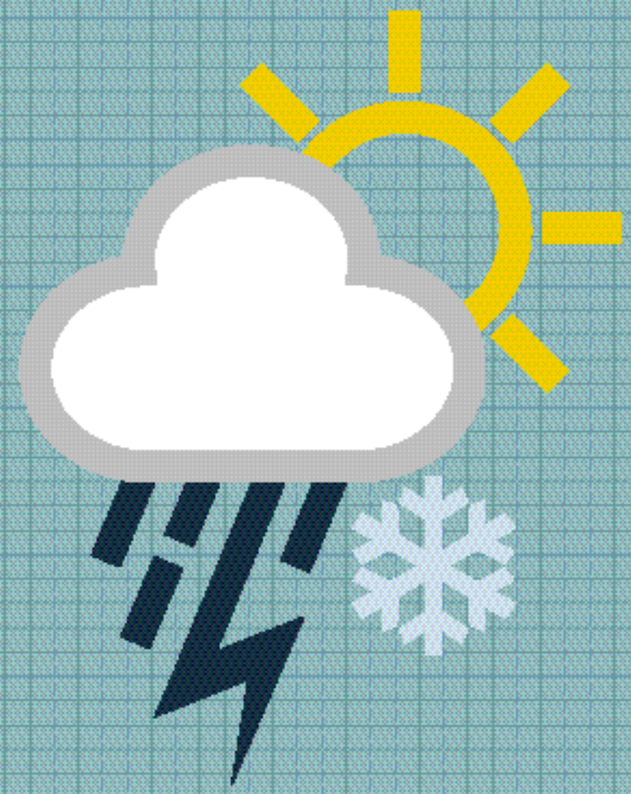
Summary report



Potential UK adaptation strategies for climate change

May 2000

Produced for the Department of the Environment, Transport and the Regions
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ERM

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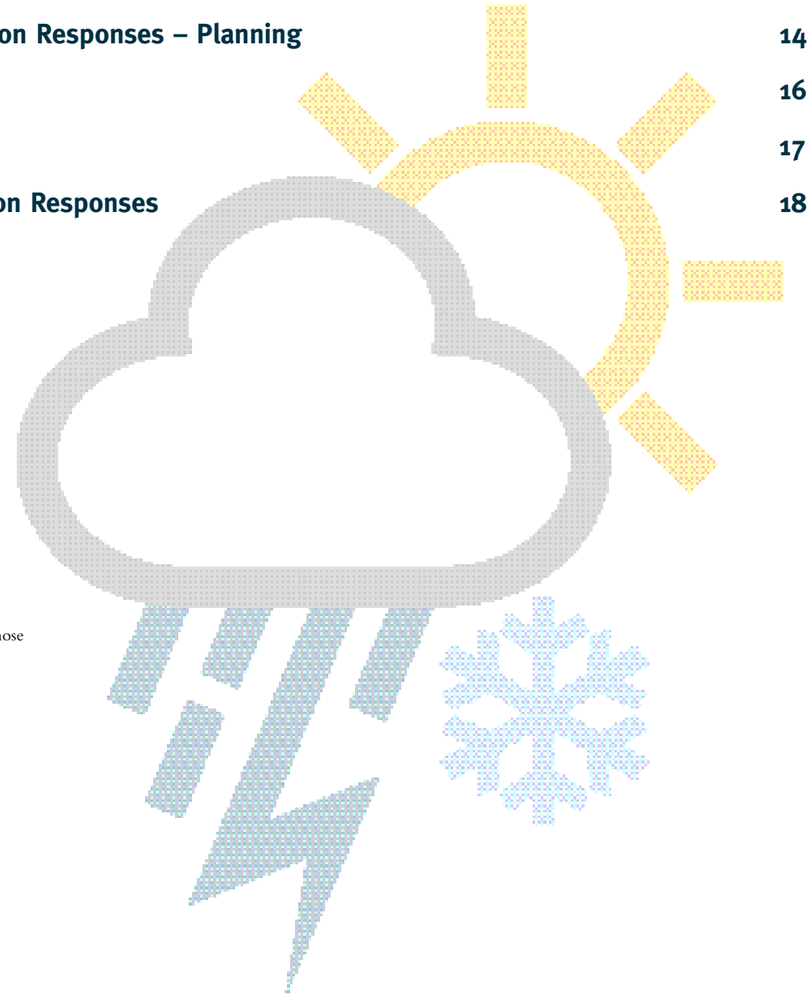
Contents



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1 Introduction

The UK Draft Climate Change Programme recognises the need to adapt to climate change in addition to reducing emissions of greenhouse gases. This work was commissioned to identify adaptation priorities for the UK to inform the development of adaptation strategies.

This study complements the longer term research on climate change impacts being undertaken by the UK Climate Impacts Programme (UKCIP). The UKCIP was established by the Government to co-ordinate and integrate a stakeholder-led assessment of the impacts of climate change at a regional and national level. UKCIP has developed a set of scenarios for climate change, the UKCIP98 scenarios, which provide the common basis for regional and sectoral studies.

This work has been undertaken by a team of specialists led by Environmental Resources Management (ERM) on behalf of the Department of the Environment, Transport and the Regions (DETR). It has involved numerous stakeholders in reviewing impacts, considering possible adaptation options, and defining the priority responses.

The Case for Adaptation

As early as 1996 the Intergovernmental Panel on Climate Change (IPCC) concluded that, *"the balance of evidence suggests that there is a discernible human influence on the climate."* Under a 'business as usual' climate change scenario, the latest results from the Hadley Centre indicate that we would expect to see a further 3°C increase in global average temperature by 2100. If we were to stabilise concentrations of carbon dioxide in the atmosphere at 550ppm (the level proposed by the EU to guide emissions reduction efforts) this would result in a temperature rise of about 2°C. In fact, stabilising global concentrations at today's levels would require cuts in emissions of 60–70% now, and even then temperatures would still rise by 0.5°C.

Changes in climate will increasingly present risks to people, property and natural resources, but will also create new business and life style opportunities. Some form of carefully planned adaptation will be required.

However scientists and policy makers still do not have a full assessment of the implications of climate change and how it is going to affect the way we live and work. The challenge for policy makers, business strategists and individuals is to understand:

- the nature and scale of climate change risks;
- where we need to take active steps to adapt to unacceptable risks or to capitalise on opportunities.

Climate Change Scenarios

The UKCIP98 scenarios centre on the 2020s, 2050s and 2080s. The major changes indicated by the scenarios include:

- Rising mean annual temperatures, which could be between 0.9°C and 3.2°C higher than the 1961–90 average by the 2080s, especially in the South East.
- Mean annual rainfall could increase by 0–10% by the 2080s. Although these mean increases are modest, summers are likely to be drier, especially in the South East, and winters and autumns could become wetter over the whole of the UK (by up to 20% for some scenarios). Precipitation variability could increase almost everywhere and in every season, and drought is likely to become more common.
- Mean increases in sea level by the 2050s could vary from as little as 2 cm net in west Scotland (low scenario) to as much as 83 cm net in East Anglia (high scenario), taking into account natural land movements.
- Changes in the frequency of extreme events are difficult to predict. There are also uncertainties associated with modelled changes in future wind regimes. Intense daily precipitation events could become more frequent, but daily-mean wind extremes may show little change. Storminess may change little although summer gales and extreme winter gales are likely to become more frequent.

Reference: Hulme, M and Jenkins, GJ (1998). Climate Change Scenarios for the United Kingdom: Scientific Report. UKCIP Technical Report No. 1, Climate Research Unit, Norwich, 80pp.

The Study Approach

This study takes a first look at possible adaptation priorities for the UK, and specifically:

- reviews priorities for possible adaptation responses over the next 30 to 50 years;
- assesses the relevance of a cost-benefit analysis (CBA) framework in the climate context characterised by uncertainties and the need for a precautionary approach to risk; and
- identifies the financial costs for options to address key adaptation priorities.

The study draws conclusions on the types of responses that need to be anticipated and planned for and those which may be left to follow their natural course. It also identifies a set of 'no regrets' actions in a wider sustainability context. finally the study highlights the actions on adaptation which the Government, devolved administrations and others may have to consider.

A full explanation of the process involved in the study, the findings, assumptions on which they are based and their implications, is available in the companion Technical Report (Potential UK adaptation strategies for climate change, Technical Report, May 2000. Product code 99DPL014). In reading the Summary Report it should be recognised that the work is an initial attempt to focus on priorities at the UK level for the next 30 to 50 years, and to understand their costs. Cost estimates are based on limited data and may not be comparable between sectors. Cost estimates are also preliminary in nature and should not be assumed to be definitive. In some cases, where the understanding of impacts, availability of data and thinking about adaptation is most advanced, it has been possible to identify regional differences in approach – for example with water resources.

All sectors of the economy, environment and society may be vulnerable and need to adapt. However, this work does not attempt to describe comprehensive adaptation requirements across all regions and sectors, which will be the focus of subsequent more detailed work.

The process followed to identify priorities, cost responses and draw conclusions is summarised below.

1. Prioritising Adaptation Responses

The first step in developing adaptation responses was to assess key vulnerabilities to climate change and identify areas where implementing adaptation responses is most urgent.

The UKCIP98 scenarios (summarised on page 4) were used as the starting point for assessing likely impacts on different sectors, activities and regions. While climate change science helps define risks, public perception is also critical in deciding which risks are 'unacceptable' and require immediate action. Through the involvement of policy makers, academics, business and non-governmental organisations in a stakeholder workshop, this study has attempted to take both scientific and economic analysis and subjective judgement into account in deciding what is important. The adaptation priorities were identified as:

- water resources management;
- coastal and riverine flood protection;
- building and infrastructure design and protection;
- protection of designated habitats and species; and
- land use and sectoral planning.

A need for better climate information and awareness was also widely agreed.

2. Estimating Costs

Having identified a range of adaptation options we carried out an initial assessment of costs (both to Government and to the private sector), for both impacts and the adaptation options, over the next 30 to 50 years. Cost-benefit analysis provided the framework and a discount rate of 6% has been used throughout. However uncertainties about changes in key climate parameters (particularly extreme events), impacts (the cost of doing nothing) and possible responses mean:

- we have drawn heavily on case study experiences (similar policy actions for other purposes, analogues and proxies); and
- used information from stakeholders and expert judgements.

This has inevitably led to some inconsistencies but care has been taken to highlight our assumptions and the limitations of the analysis throughout. A major limitation in these analyses has been the inability to estimate environmental and social impacts and costs. The results of the analysis have been reviewed by a project steering group and climate and sectoral experts and their comments are reflected in the analysis.

3. Drawing Conclusions

The analysis highlights the scale of the potential costs, and where possible, who is likely to bear them. The analysis also highlights the challenges in making decisions about specific adaptation requirements at this time. However, care is required in interpreting the results. This is because the process of costing response options introduces a degree of specificity into climate change scenarios that may not be appropriate given the current state of knowledge.

2 UK Adaptation Priorities

2.1 Potential adaptation responses – water resources

Sustainable water resource management needs to reflect the possibility that as our climate becomes hotter and increasing rainfall is concentrated in shorter seasons and fewer days there may be increasing pressure on the water resources available, especially during the summer months. Stakeholders identified this as a key adaptation priority. The responses required for three scenarios (a gap between water demand and supply of 5, 10 and 20% respectively, in England and Wales over the next 30 years) and their economic implications have been explored. Pressures are likely to be less acute in Scotland and Northern Ireland. Whatever the level of stress, the adaptation challenge will be building climate headroom into resource management to provide adequate flexibility for addressing climate change impacts.

The main adaptation responses are set out below.

Adaptation Responses

- Adaptation responses will rely on various combinations of supply or household demand side options to meet the respective levels of shortfall, while not pre-judging or favouring any particular option.
- Supply side options include reservoirs, conjunctive use schemes (storing winter river flows in uplands and as groundwater for release during summer months), bulk transfer schemes, leakage reduction and desalination plants.
- Residential water demand management options include using water-efficient domestic appliances, rainwater collection, grey water recycling, cistern dams, tap restrictors, water meters and changes in behaviour.

Table 1a shows indicative costs for using different supply options while **Table 1b** shows the implications of residential demand side options to meet shortfalls in water availability, using illustrative figures for water delivered and water supplied. The estimates include discounted capital and operational costs over 30 years. It should be noted that supply side options relate to the entire potential resource gap while demand side measures relate to about half this volume of water, which is the proportion delivered to households. Reliable data for industrial and agricultural demand side options are not currently available.

Key Assumptions for Developing Adaptation Responses in the Water Resources Sector

- According to UKCIP98 medium and high scenarios, there may be an overall increase in mean annual rainfall, but increased probabilities of warm/hot seasons/years and dry season/years – ie. hot dry summers.
- Water availability is expected to decrease, particularly in south and east England and Wales due to reduced supply and increased water demand.
- In identifying adaptation options we have assumed available water supply in England and Wales will decrease by 5%, 10% or 20% by 2030 (although there is no certainty at this time about the changes that may actually happen).
- England and Wales have been grouped together for the purposes of this exercise, and to simplify the estimation of possible adaptation costs it has been assumed that all regions within England and Wales would be equally affected by climate change. However, this is unlikely to be the case.
- Best available evidence suggests water availability may be less of an issue in Scotland and Northern Ireland.
- There may also be deterioration in water quality, although current research does not provide a basis for identifying response options or what they might cost.

Implications for Water Resources Adaptation

Supply side measures are likely to be more costly than demand side measures, even before environmental impacts on aquatic systems and riverine habitats (which have not been included here) are taken into account. The demand side measures do not consider the social costs associated with changing behaviour by individuals, such as grey water use etc. Responses are likely to comprise a combination of supply and demand side measures.

Regardless of the technical options selected, water users are likely to bear most of the cost of adaptation, either through increased water charges or by bearing the direct costs for implementing demand side measures. There are 'no regrets' actions which could help minimise costs if undertaken in the short term, as set out below.

'No Regrets' Actions

- Awareness raising of water scarcity issues.
- Demand side management measures, perhaps to achieve up to 5% savings in residential water use.
- Addressing leakage reduction in priority areas, based on consideration of the costs and benefits.

There is a need for more detailed scientific data and agreement on a methodology for dealing with uncertainty between water companies, OFWAT and the Environment Agency as a basis for agreeing what types of measure are justified and feasible and what their implications will be for financing and water pricing.

In order to make informed investment decisions – whether we start now or defer for a few years – costs on this scale need to be compared with the potential costs of inaction. The full costs of water shortages will include disruption to industry, social costs of limiting residential use (particularly the use of stand tankers and stand pipes, or hose pipe bans), and costs to water companies for short term measures to meet essential uses. Reliable estimates of these costs are not available, although 'willingness to pay' evidence suggests they could easily be over £10 per household per year, and more for water dependent businesses.

Once the full costs of water shortages are taken into account, measures which anticipate a 5% or even 10% shortfall are likely to start looking attractive. Furthermore when the associated energy savings from demand side measures are taken into account there may be 'no regrets' in climate terms about investing to save 5% of residential water demand. Beyond 10% savings in residential water demand costs are likely to start escalating sharply. However, even promoting demand side savings of 5 or 10% would require concerted efforts by Government, water companies and NGOs to raise consumer awareness of climate issues and a clearer financial framework to provide incentives for water companies to promote demand management on the scale required.

Table 1a Supply Side Measures to Adapt to a Gap in Water Resources

Supply Option	5% shortfall by 2030[1]	10% shortfall by 2030[1]	20% shortfall by 2030[1]
	Range from lowest to highest cost options		
Reservoir Development	£30–£230 million	£60–£450 million	£110–£900 million
Conjunctive Use Schemes	£1,300–£11,100 million	£2,600–£22,300 million	£5,200–£44,500 million
Bulk Transfers	£5–£820 million	£10–£1,600 million	£20–£3,300 million
Desalination	£40–£110 million	£90–£220 million	£170–£440 million

Costs are presented as net present values, discounted at a rate of 6% over 30 years.
Cost estimates are based on information from OFWAT reports and the Environment Agency, and discussed with DETR, Environment Agency, National Assembly for Wales and Institute of Hydrology. Full details can be found in Chapter 4 and Annex C, Technical Report.
1 Based on an illustrative figure of 15,100 Ml/day water into supply (OFWAT's 1998/99 figure)

Table 1b Residential Demand Side Measures to Adapt to a Gap in Water Resources

Scenario	5% shortfall by 2030[1]	10% shortfall by 2030[1]	20% shortfall by 2030[1]
Saving 5% of water supplied[2]	£5 million		
Saving 10% of water supplied[2]		£10 million	
Saving 20% of water supplied[2,3]			£80 million

Costs are presented as net present values, discounted at a rate of 6% over 30 years.
Cost estimates are based on information from OFWAT reports and the Environment Agency, and discussed with DETR, Environment Agency, National Assembly for Wales and Institute of Hydrology. Full details can be found in Chapter 4 and Annex C, Technical Report.
1 Cost estimates assume the most cost-effective options would be taken up first (ie tap restrictors) and the most expensive options (ie domestic appliances) would only be used when the capacity of cheaper options has been exhausted.
2 Based on an illustrative figure of 8,350 Ml/day water delivered to households (OFWAT's 1997/98 figure)
3 This includes the increased use of water-efficient domestic appliances which tend to have a higher cost/Ml, but are deemed preferable by the consumer over using rainwater collection beyond about 16% of domestic water uses (mostly for flushing).

2.2 Potential adaptation strategies – flooding

Increases in mean rainfall, sea level rise and the possibility that extreme events – storminess, heavy rain and sea surges – may become more frequent imply an increased risk of flood occurrence. The assumptions developed with stakeholders and summarised below, suggest that those living in coastal areas or in river floodplains will be exposed to increased risks of flooding that might translate to a doubling or tripling of flood damages over the next 50 years. Developing an adaptation response for flooding requires:

- an understanding of current flood damages;
- improved modelling or projections of climate change impacts on flooding; and
- investigations of the cost effectiveness of different investments in flood defences that could offset future damages by adapting (strengthening, realigning and extending) the current flood defence infrastructure.

The main adaptation responses are set out below.

Adaptation Responses

- Improve flood risk identification and forecasting, and awareness raising.
- Accelerate investment in existing rolling programmes of coastal and river flood defences to protect flood prone areas against increased risks from climate change.
- Avoid, or ensure adequate protection for, new development in areas likely to be at increased risk of flooding.

Increased risks of flooding would require changes in the way flood risks for both river and coastal areas are identified. In addition to ongoing research in this area, we need to develop a far better understanding of short and long term flood and storm dynamics and identification of high risk areas in floodplains and around the coast. Better knowledge needs to underlie the process of prioritising where and when expensive flood defences should be built. However additional spending on the identification of high risk areas – whether by Government agencies, the business sector or academic institutions – is likely to be relatively modest in comparison to the costs of flood defence infrastructure, summarised in **Table 2** . In coastal areas additional expenditure would be required to strengthen and perhaps realign existing defences, while in river floodplains a combination of strengthening and realigning existing defences and defending some new areas would be necessary.

Initial estimates suggest the costs of improving flood defences to adapt to increased coastal and riverine flood risks would be in the region of £1.2 bn for England and Wales and £16 mn for Scotland over the next 50 years. The majority of expenditure is expected to be on the east coast of England. These costs do not include any expenditure by the public or businesses in flood proofing. Nonetheless the overall costs may be much less than the costs of large scale flood damage to life and property, which are illustrated in the box on page 9.

Implications for Flood Prevention Adaptation Measures

The analysis suggests the costs of investing now to protect coastal property in England and Wales could be a similar order of magnitude as the additional damages which might occur without adaptation. Decisions about adaptation would need to be made on a case by case basis. In coastal areas in Scotland, and for river flooding in England, Wales and

Key Assumptions for Developing Adaptation Responses to Increasing Flood Risks

- An increase in damages caused by riverine flooding by a factor of 2 or 3 over the next 50 years is assumed across the UK. To address these impacts an additional £24.5 and 0.5 million might be required each year for 50 years for riverine flood defences in England and Wales, respectively. An additional £19 million might be required each year for 10 years in Scotland.
- An increase in damages caused by coastal flooding by a factor of 2 or 3 over the next 50 years is also assumed.
- To address these impacts an additional £50 million might be required each year for 50 years to strengthen and maintain coastal flood defences in England and Wales, of which £0.5 million might be required in Wales. An additional £1.25 million might be required each year for 10 years in Scotland.
- No data is currently available for climate risks, increased damage costs or costs of adaptation for Northern Ireland.

Table 2 Adapting to Increased Coastal and Riverine Flood Risks

Adaptation Response	Adaptation Costs	Costs of Doing Nothing[1]
England and Wales		
Strengthen and adapt coastal flood defences[2]	£0.8 billion	£0.4 to 0.9 billion
Strengthen and adapt river defences[3]	£0.4 billion	£1.3 to 2.7 billion
Scotland		
Strengthen and adapt coastal flood defences	£1 million	£4 to 9 million
Strengthen and adapt river defences	£15 million	£115 to 225 million

Costs are presented as net present values, discounted at a rate of 6% over 50 years.
Cost estimates are based on information and advice from MAFF, Environment Agency, SEPA, National Assembly for Wales, Rivers Agency, Northern Ireland, Centre for Coastal and Marine Studies and Institute of Hydrology. Full details can be found in Chapter 5 and Annex D, Technical Report.
1 The costs of doing nothing have been calculated as the costs of doubling or tripling of flood damages caused by climate change over the next 50 years. Data is not available for Wales.
2 £10 million of the NPV adaptation costs for strengthening coastal flood defences would be required in Wales.
3 £10 million of the NPV adaptation costs strengthening river defences would be required in Wales.

Scotland, climate-related flood defence investments are likely to cost significantly less than the climate-related damage that might be expected.

The costs of public sector investments (central Government and local authorities) in flood defences would be expected to be met through general taxation. While some of these costs may be passed on to local residents and businesses in the form of higher council taxes and higher insurance premiums, the majority of the costs would be spread across the population and across all regions. In general, this would not be the case with increased flood damage costs, which would be incurred by those living and working in the coastal and river floodplain areas at risk of flooding. There are 'no regrets' actions which could help minimise costs if undertaken in the short term, as set out below.

'No Regrets' Actions

- Improve flood risk identification.
- Raise awareness of practical steps to minimise exposure to flood damage risks.
- Use planning and insurance to help discourage future development in high risk areas.

Whether or not we choose to invest in flood protection infrastructure, there is a case for increasing household and business access to information about flood risks. Such information would improve investment decisions and could, for example, be factored into land use planning, mortgage or leasing processes. Inferring this information from insurance premiums does not provide sufficient detail for property owners to minimise their exposure to risks.

Damage costs of extreme flood events in the London area

In 1953 the surge tide of the Thames rose 3.7 feet above the high water level of a high spring tide. This broke flood defences along the east coast of England, and some 160,000 acres of farmland were flooded together with 24,000 homes, 200 major industrial premises, 200 miles of railway, 12 gasworks and 2 large electricity generating stations. Over 300 people were drowned as well as thousands of cattle, sheep, pigs and poultry. Gilbert and Horner (1984) estimated the damage costs of the event by comparing costs from flooding in Hamburg in 1962. Their estimates of direct damages were around £1,000 mn at 1966 values, with the costs of disruption to business etc costing a further £1,000 mn. This translates to a total of about £19 bn at today's prices and compares with the £400 mn construction cost for the Thames Barrier.

Major investments in flood defences since 1953 have eliminated significant flood damages from similar events. For example the Thames Barrier provides a 1 in 1,000 year standard of protection, and took into account sea level rise predicted for the 2040s. The Environment Agency is revising the strategy for managing the Thames Barrier, to take into account the effects of climate change, although the findings are not yet publicly available.

Reference: Gilbert, S and Horner, R (1984) The Thames Barrier. Thomas Telford Ltd, London.

2.3 Potential adaptation responses – buildings and infrastructure

Many of the climate changes identified in the UKCIP98 scenarios will affect buildings and infrastructure, causing damage to their external fabric, increasing vulnerability to extreme events, and leading to deterioration of internal conditions. Higher temperatures could dry out soils, increase subsidence, and cause ventilation problems during hot summers. Wetter winters could increase condensation and mould, driving rain could penetrate building fabrics. Increased storminess and flooding could damage infrastructure and disrupt services. To address these risks the challenge is to build sufficient 'climate headroom' into building and infrastructure design codes and existing structures so they can withstand changing weather conditions.

The main adaptation responses are set out below.

Adaptation Responses

- Revise specifications for construction and services to factor in climate change.
- Implement these specifications in new buildings and infrastructure.
- Retrofit, refurbish and maintain the existing stock to meet new/revised specifications.

An initial assessment by the Building Research Establishment (BRE) of likely climate change impacts on building regulations and standards suggests that technical guidance documents on 14 aspects of the Building Regulations used in England and Wales, Scotland and Northern Ireland, and 81 British Standards for building and construction would require review to address likely climate change impacts. The review could be achieved at little or no additional cost by integrating climate considerations into the normal review timetables, provided that adequate, detailed information on risk and uncertainty is available.

The cost of adapting new and existing buildings to meet these standards could, however, be significant. The best information on the costs of incorporating 'climate headroom' into new and existing buildings comes from projects which incorporate 'ecological' design features, such as the INTEGER Millennium House and the Environment Building. These design features cover both adaptation to the effects of climate change and energy efficiency measures. No data are publicly available on new commercial buildings or the rate of refurbishment of the residential stock. Estimated costs for adapting new residential buildings and existing commercial buildings as the stock is upgraded are given in **Table 3** .

There is little information on the 'climate headroom' required in designing and maintaining infrastructure. The utilities and transport sectors have recently started assessing the risks of climate change to their operations. Current thinking suggests that re-designing infrastructure (eg. the electricity supply network) rather than strengthening current assets will be most cost effective. Reducing future transmission requirements by decentralising generation capacity (eg. by installing small scale Combined Cycle Gas Turbines close to population centres and increasing use of Combined Heat and Power) is likely to be more cost-effective in the long term than duplicating the existing transmission grid or putting transmission lines underground which is likely to be 10 to 20 times more expensive. The opportunity costs of interrupted services if 'no action' is taken are likely to be high. An assessment has not yet been undertaken to identify the components of the electricity supply network most vulnerable to the effects of climate change.

Implications for Buildings and Infrastructure Adaptation

Defining both the technical requirements and their associated costs are difficult given the uncertainties implicit in the future climate change scenarios and the need for precision in defining design specifications for infrastructure. However, the analysis suggests a 1–5% increase on current construction costs, which could cost some £26 bn aggregated over the entire building stock.

Additional costs will initially be met by the building owners and service providers who will pass costs on in increased property prices, rents, leases and user charges or insurance premiums. The costs of not adapting buildings could also be very high to individuals and businesses, in terms of increased insurance premiums, repairing climate-related damages, and/or loss of services and disruption to business.

Table 3 Meeting Climate Sensitive Building Regulations and Standards

	Residential	Commercial
Existing Stock	22 mn	500 mn m²
New units to 2030[1]	5.5 mn	Data not available
Incremental costs of adaptation	1–5%	1–5%
Total Costs	£2.2–15.5 billion	£1.5–10.4 billion

Costs are presented as net present values, discounted at a rate of 6% over 30 years.
Cost estimates are based on information from DETR, Royal Institute of Building Surveyors and building demonstration projects, and advice from CIRIA. Full details can be found in Chapter 6 and Annex E, Technical Report.
1 DETR figures to 2016 extrapolated on a linear basis to 2030.

The challenge will be to ensure that adapting buildings for climate change is undertaken in association with other changes such as those to increase energy efficiency, so that these additional costs can be off-set against reduced operating costs. Possible 'no regrets' actions are summarised below.

'No Regrets' Actions

- Incorporate 'climate headroom' and energy efficiency measures into new/revised building standards/guidance.
- Raise awareness of the importance of 'climate headroom' in retro-fitting and refurbishment.

The process of finding the best adaptation solutions would need to involve many different stakeholders, including regulators, planners, designers, regeneration agencies, local authorities, housing associations and all those involved in the building chain through to financiers and insurers.

Key assumptions for Developing Adaptation Responses for Buildings and Infrastructure

- All buildings and infrastructure would be affected in some way by climate change, and in time would have to incorporate 'climate headroom' to ensure they can adapt to a changing climate. However the rate and extent of potential climate impacts on buildings and infrastructure is likely to vary considerably, in time and space.
- As the basis for estimating the costs of adaptation we have drawn on current information about the existing stock of buildings and infrastructure, and used projections or made assumptions about the future stock:
  - There are currently 22 million dwellings in England and Wales and DETR has predicted a 3 million increase in dwellings by 2016. Extrapolating this rate of increase on a linear basis suggests an additional 5.5 million dwellings by 2030.
  - BRE has estimated that there is 70.7 mn m² of office space, 94.2 mn m² of retail space and 332.9 mn m² of industrial space. There are no projections for new commercial buildings.

2.4 Potential adaptation responses – nature conservation

Climate change could significantly affect nature conservation. The most pronounced effects are expected in coastal and upland areas. Biodiversity could also be affected indirectly by adaptation responses in other sectors, for example, water usage and agricultural land use.

Key Assumptions for Developing Adaptation Responses for Nature Conservation

Key climate change impacts on nature conservation identified in the Government's Climate Change Impacts Review Group 1991 and 1996 reports and by Institute of Terrestrial Ecology experts as part of this study are likely to include:

- Loss of about 10% of designated areas with a 1–2°C increase in mean annual temperature. Under the UKCIP98 scenarios this order of temperature change is expected between the 2020s and 2050s.
- The species in about half of all designated areas may be significantly affected by a 1°C increase in mean annual temperature. Under the UKCIP98 scenarios this would happen by the 2020s.
- Climate related impacts in designated areas are likely to be disproportionately focused on coastal and upland habitats.

In this initial study we have assumed that:

- 10% of designated areas (by area) would not meet their nature conservation objectives by 2030.
- Due to the combined influence of temperature, rainfall, sea level and storm surge impacts some 25% of coastal designated habitats could be lost at a linear rate to 2030.
- All types of designated coastal habitat would be equally susceptible to climate change, although in reality this is unlikely.

Impacts are expected to be significant, but are extremely uncertain, reflecting the limited state of knowledge of how individual species and habitats will react to climatic stresses and their relative importance in ecosystem functions.

A comprehensive adaptation strategy for nature conservation would need to consider a large range of possible impacts and responses for different species and habitats. The assumptions developed with stakeholders for this initial study (and summarised below) suggest the most critical adaptation response must be to maintain the network of designated areas, because of their legal status and accompanying international obligations to conserve biodiversity at internationally recognised sites. These actions will need to be considered in the context of protecting and enhancing biodiversity in the wider countryside.

The main adaptation responses are set out below.

Adaptation Responses

We have considered a framework of three response options for the most at risk designated areas:

- relying on natural migration processes;
- a facilitated colonisation process involving removal of barriers to natural ecological processes; and
- wholesale re-creation or restoration of habitats which are under serious threat.

This initial analysis focuses on coastal habitats since the techniques and costs of different management options are best known. Cost data has been drawn from case studies in the UK and covers the tapestry of habitats – sand dunes, salt marsh, mudflat, saline lagoons and shingle – with high conservation value in coastal areas. Cost estimates are presented in **Table 4** .

Table 4 Adaptation Responses in Designated Coastal Areas

Habitats	Designated area (England)[1] (ha)	Risk of doing nothing – assumed loss of designated habitat by 2030 ha)[2]	Discounted costs of adaptation esponses[3] (£million)	
			Lower estimate	Higher estimate
Salt marsh[3]	32,425	8,100		
• colonisation			5	110
• re-creation			20	370
Sand dunes	10,710	2,680		
• re-creation			10	20
Saline lagoons	1,120	280		
• re-creation			1	10
Mudflat	200,000	50,000		
• re-creation			130	1000
Grazing marsh	11,000	2,750		
• re-creation			1	4
Total	**255,255 ha**	**63,810 ha**	**147–162**	**1144–1404**

Costs are presented as net present values, discounted at a rate of 6% over 30 years.
Cost estimates are based on information and advice from English Nature, MAFF, Cambridge Environmental Resource Consultants Ltd, many case studies of habitat recreation and rehabilitation, and advice from DETR, Scottish Natural Heritage, Countryside Council for Wales, Department of Environment, Northern Ireland, and the Institute of Terrestrial Ecology. Full details can be found in Chapter 7 and Annex F, Technical Report.
1 Data on habitat types are only available for designated areas in England
2 Assuming 25% of designated areas will no longer meet nature conservation objectives by 2030
3 Cost estimates for salt marsh assume all designated areas are subject to facilitated colonisation or re-creation, but not a combination. Cost data for facilitated colonisation is not available for other habitats.

Implications for Nature Conservation Adaptation

The analysis implies potential adaptation costs in the range of £150–1,400 million over 30 years, of which the costs of recreating mudflats would be the largest area contributor. The uncertainty in these cost estimates reflects the different approaches used in different case studies and the bias of case studies in favour of expensive re-creation options as opposed to less costly facilitated colonisation. For instance the cost estimates do not necessarily include the cost of loss of productive land. There are 'no regrets' actions which could help minimise costs if undertaken in the short term, as set out below.

'No Regrets' Actions

- Improve protection and management of existing designated areas.
- Ensure policy builds on the natural dynamics of ecosystems and incorporates buffer zones in designated areas.
- Incorporate opportunities to facilitated colonisation in agri-environment schemes, flood defence schemes and coastal planning.

We have not been able to put monetary values on the costs of doing nothing. The environmental and social costs of losing the conservation value of up to one quarter of coastal designated areas is difficult to quantify. However significant public support for safeguarding biodiversity would make 'no action' unlikely.

Most direct adaptation costs are likely to fall to the public sector, although the voluntary sector and individuals currently contribute almost half of total expenditure on biodiversity – and so are likely to meet some costs. Indirect costs are also likely to fall to those whose land and outputs are lost to migrating habitats.

Respect for the dynamic nature of natural and semi-natural ecosystems is the key to future adaptation. This might mean incorporating buffer zones in new designations so that surrounding areas are managed in sympathy with the objectives of the designated area. Meeting objectives over a larger area should provide flexibility in how they are achieved.

2.5 Potential adaptation responses – planning

Land use planning and strategic sectoral planning are likely to be two of the key tools for adapting to climate change. For example, they could be used to deal with flooding, shortage of water, poor urban quality and anticipating opportunities from climate change.

Land Use Planning

Without the full integration of climate change considerations in land use planning, market mechanisms could continue to encourage development in areas that are vulnerable to the effects of climate change (eg. sea level rise, riverine flooding and subsidence). This could lead to social and economic costs through large scale blight of these areas as the risks emerge over time. Insurance companies tend to review premiums on an annual basis, changing the level, nature and geographic coverage of insurance cover in response to high risk events. Properties could become difficult to insure and lose value. The insurance industry has indicated that it does not wish to withdraw cover and would continue to offer cover if adequate levels of protection against flooding could be maintained by Government and others.

Land use planning processes can provide a very effective tool for taking a longer term view on where and when development should take place under a changing climate. For example, by discouraging future development in high risk areas and encouraging the phased roll back of development and housing from high flood risk zones. Climate assessments should be built into existing planning guidance, structure and local plans, shoreline and estuarine plans as they are produced and/or reviewed on regular cycles.

Strategic Sectoral Planning

At the sectoral level strategic planning which takes climate change into account will be an important tool for ensuring that potential opportunities – new crops, increased tourist and visitor numbers, new products and services – are realised by small agricultural, tourism and manufacturing businesses that tend to work to short planning horizons. These sectors are highly adaptable but may be unaware of their options and unable to act alone.

More strategic assessments will be needed to identify and capitalise on climate related opportunities, and to manage any associated financial, environmental or social transition costs. In the case of agriculture the price support mechanism provides a powerful lever for influencing farmers' crop choices and production systems. Climate change needs to be factored into EC programmes and UK agri-environment schemes, and advisory services would have a role in ensuring farmers receive good advice.

The tourism sector is highly fragmented, comprising many small businesses each responding reactively to change. While the impacts of warmer, drier summers on visitor numbers and specific destinations is highly uncertain, strategic thinking and planning for accommodation, traffic and attractions' capacity will be required if resorts and small businesses are to realise the potential benefits from climate change. Mechanisms for co-operation and communication within the sector will be required so that individual businesses can make climate-oriented investment decisions. An example of tourism sector planning is provided on page 15.

Implications for a Climate Sensitive Planning Process

The direct costs of land use planning and strategic sectoral planning which incorporate climate assessment and build in flexibility for climate impacts will be insignificant in comparison to flood, water resources, nature, and buildings and infrastructure adaptation or the costs of doing nothing. Climate related planning could also bring other benefits such as regeneration of urban areas and improved management for conservation and leisure. Direct costs of adaptation that will be incurred relate to broadening and co-ordinating planning processes and educating and raising awareness of decision makers at all levels – in central and local Government, businesses and their advisors – about how to build climate flexibility into plans.

'No regrets' actions which could help minimise costs if undertaken in the short term are set out below.

'No Regrets' Actions

- Planning processes which integrate climate risks into strategic plans, and engage the insurance industry.
- Risk assessments of the threats and opportunities associated with climate change in key sectors and regions.

Zoning of land uses according to its vulnerability to climate and suitability for development, particular economic activities and infrastructure, could have additional indirect costs which will be more difficult to measure but potentially far greater. Possible consequences of such zoning may include a longer process for obtaining planning permission, and demarcation of 'flood risk zones' with the associated additional pressures on land and property prices and increased pressure to develop in green-belt areas.

The availability of insurance cover could provide an important driver in supporting the transition towards a climate sensitive economy and land use system. This needs to be done gradually, sensitively and integrated into strategic planning to ensure that the transition costs to society are not unacceptably high. This may require changes in the industry's planning processes and even some Government intervention to ensure equity in the sharing of costs and benefits of climate change.

Strategic Planning in the Tourism Sector

Changes in leisure and travel patterns as a result of climate change could create substantial opportunities for the tourism sector in many parts of the UK. A warmer summer climate could attract holiday-makers (particularly if they are accompanied by hot summers more in line with traditional southern Mediterranean holiday destinations) and even small changes in behaviour could have a major effect. Tourism numbers could increase in many parts of the UK.

Additional leisure travel in the UK could change transport infrastructure requirements, accommodation, employment patterns, the demand for labour, training, information services, marketing, environmental management, local government revenues and capital budget allocations. Regional authorities and tourism stakeholders need to consider the capacity of natural resources and infrastructure to cope with climate induced changes in demand, particularly in peak periods, and plan for growth accordingly.

3 Discussion

The adaptation priorities reported in this study were determined through stakeholder consultation at a workshop. The study suggests that land use and sectoral planning could play a key part in addressing the cross-cutting nature of climate change adaptation.

Focusing on UK wide adaptation responses...

This process focused on identifying adaptation priorities in response to:

- the key climate change impacts over the next 30 years, on the basis of urgency, importance to the UK economy, scope for a strategic response and public perception; and
- options for adaptation responses that would address the priority impacts.

The stakeholders involved in this process (a small group of analysts and decision-makers from private, public and voluntary sector organisations) agreed that action is required across a wide range of areas, but specifically on:

- water resources management;
- coastal and riverine flood protection;
- improved building and infrastructure design and protection;
- protection of designated habitats and species; and
- land use and sectoral planning.

A need for better climate information and awareness was also widely agreed.

Recognising that regional priorities may be different...

All sectors of the economy, environment and society are vulnerable to climate change. It is possible that a different group of stakeholders, or a more specific sectoral or regional focus in the study, might have identified different priorities. For example some regions may consider that water resources or flooding may be less pressing priorities, and believe that tourism and agriculture sectors require special attention. The model for a stakeholder-led approach and regional work undertaken by UKCIP offers a good framework for identifying adaptation priorities and responses at a regional level.

And that costs will be substantial...

A cost-benefit analysis (CBA) framework was used to assess the costs of implementing options to respond to the identified adaptation priorities over the next 30 to 50 years. The analysis illustrates the high costs in implementing some of the priority adaptation responses even when discounted over 30 years. For example:

- strengthening coastal and river flood defences to withstand climate changes could cost £1.2 billion for England and Wales; and
- building 'climate headroom' into new houses in England and Wales could cost up to £15 billion.

But can be minimised with careful planning...

Costs on this scale would have major implications for public spending and cost to business and others, and emphasise the need to:

- build potential spending requirements into existing processes and cycles;
- spread investments over the next 30 years in areas at greatest risk; and
- take climate change into account in all new development.

On the basis of better decision making...

Cost-benefit analysis is a widely used tool for making policy, programme and infrastructure investment decisions in other areas. However using it to assess adaptation costs has major limitations due to:

- the uncertainties surrounding climate impacts;
- the difficulties of putting monetary value on environmental and social damage; and
- the nature of discounting which generally results in deferred action being the most attractive option.

And more flexible tools...

Given the potential scale and uncertainty of adaptation costs there is a need for further, detailed assessment of adaptation options and their associated costs. Work needs to focus on reducing uncertainties and better quantification of environmental and social costs and benefits. It also seems prudent to use additional decision tools such as multi-criteria analysis which provide more flexibility in dealing with risk, uncertainty and non-monetary estimates of social and environmental costs and benefits.

4 Next Steps

Improving the basis for decision making...

Decision makers require better information to make informed decisions about adaptation. The UKCIP is designed to improve understanding of impacts and to support stakeholders in developing their adaptation strategies. UKCIP will further develop scenarios and undertake regional interpretation of results. Better temporal and spatial resolution will help to define risks more accurately, while different decision tools and evaluation techniques will provide a wider context to decisions.

With wider involvement of stakeholders...

A wider range of stakeholders needs to be involved in prioritising adaptation responses, ensuring sharing of costs and benefits, identifying opportunities for integrating adaptation into other policies, plans and projects.

Within a co-ordinated policy framework...

A framework to integrate adaptation requirements into policies, plans and projects is likely to be necessary.

While sharing costs equitably...

The analysis shows that many of the costs of adaptation will fall, directly or indirectly, on the general public and businesses. These costs are unlikely to fall evenly temporally or spatially.

There is a presumption that insurance will continue to be available and affordable in all areas and for all types of climate risk. The insurance industry is currently assessing climate risks. Any decision to withdraw or reduce the level of insurance cover could have significant impacts on households and businesses with fixed assets in high risk areas.

And integrating climate into wider sustainability thinking...

Adaptation responses are likely to be most cost-effective where they are integrated into existing plans, programmes and projects. Sustainable development offers the best framework for thinking more widely about 'no regrets' approaches to climate change adaptation.

And taking early action on 'no and low regrets' measures...

There are 'no regrets' actions that can be taken at both the sectoral (pages 18–19) and wider level. The latter are presented below.

Wider 'No Regrets' Actions

- Improving information, to make more robust predictions of climate change impacts and narrow the range of assumptions about adaptation responses.
- Raising awareness about the need for adaptation, with the general public that may incur the costs and with business that may capitalise on the opportunities.
- Integrating adaptation responses into existing policies, plans, programmes and projects, particularly for water resources, buildings and infrastructure.
- Using planning tools, such as strategic environmental assessment and environmental assessment (EIA), to introduce the need for adaptation in new policies, plans, programmes and projects.
- Ensuring that climate flexibility and sustainability thinking is fully integrated in policies, plans, programmes and projects, to ensure that adaptation is only one of a number of benefits delivered by particular actions.

5 Summary of Adaptation Responses

	Water Resources	Flooding	Buildings and Infrastructure	Nature Conservation	Planning
Context	Drier summers and increased frequency of drought Emerging gap between supply and demand, especially in the south, east and Wales Assume the demand-supply gap is 5, 10 or 20%	More rainfall through the year Increased rainfall intensity Sea level rise Increased risk of storm surges Increased risk of flooding in coastal and river areas Assume there is a two to three fold increase in flood damages caused by climate change	Increased temperatures Increased incidence of extreme events Increased wear on building fabrics Deterioration of internal building environments Damage to infrastructure and disruption of services	Most key habitats and many species may be subject to some change, coastal areas more than others Not all species and habitats will be able to adapt as fast as climate is changing This may affect the conservation status of designated areas There could also be some opportunities for biodiversity	Future land use planning needs to consider changing suitability for different land uses Regions are likely to develop different responses to climate change impacts Business and industry may experience changes in their operating conditions, which could create risks and opportunities
Responses	Close the gap between supply and demand in England and Wales, using: • supply side measures • residential demand management measures Note that residential demand side management relates to only half of water used; more work on opportunities for industrial and agricultural water saving is required.	Strengthen coastal and river flood defences in England, Wales and Scotland to address this increased risk Improve flood risk knowledge and awareness	Introduce additional climate headroom into buildings and infrastructure by: • developing new or revising existing building specifications, • implementing these in new stock, and • retrofitting existing stock	It has been assumed that 25% of coastal designated areas will no longer meet their objectives by 2030 Adaptation responses might be some combination of: • natural and facilitated migration • facilitated colonisation • artificial re-creation	Land use and sectoral planning processes and systems should consider cost effective means of avoiding climate risks and capitalising on opportunities
'No Regrets' Actions	Awareness raising of water scarcity issues Demand side management measures, perhaps to achieve up to 5% savings in residential water use Addressing leakage reduction in priority areas, based on consideration of the costs and benefits	Improve flood risk identification Raise awareness of practical steps to minimise exposure to flood damage risks Use planning and insurance to help discourage future development in high flood risk areas	Incorporate climate headroom and energy efficiency measures into new/revised building standards/guidance Raise awareness of the importance of 'climate headroom' in retro-fitting and refurbishment	Improve protection and management of existing designated sites Ensure policy builds on the natural dynamics of ecosystems and incorporates buffer zones in designations Incorporate opportunities to facilitate colonisation in agri-environment schemes, flood defence schemes and coastal planning	Climate sensitive planning processes which integrate climate risks into strategic plans, and engage the insurance industry Risk assessments of the threats and opportunities associated with climate change in key sectors and regions
Implications	Demand side measures appear most cost effective, although they could have considerable social impacts Supply side measures might be appropriate in some cases, if social and environmental costs are minimised The public will ultimately bear many of the costs Regulators and water companies should take account of common future climate scenarios The costs of 'doing nothing' include disruption to business and household activities caused by failure of supply	Substantial investments would be required Mainly funded through general taxation People and businesses need improved information to minimise their exposure to flood risk The costs of 'doing nothing' may include disruption to services and business activity, loss of productive land, damage to fixed assets	1–5% increases in building costs, could be substantial when aggregated Likely to be passed on to individuals and business 'Climate headroom' could be incorporated at the same time as other benefits, such as energy efficiency improvements, or decentralising energy services Costs of 'doing nothing' include disruption to services caused by climate related failures	Costs of addressing climate risks could be considerable Respect for dynamic ecosystems in designation and management of designated areas could help address impacts of climate change Most costs could fall to the public sector but the voluntary sector is also likely to contribute Costs of 'doing nothing' may include altering the basis of designated areas and responding to public pressure if designated areas are significantly degraded	Many of the required responses can be accommodated within existing planning processes Indirect costs could be considerable as development land might be reduced in some areas Integrating climate change adaptation requirements into current planning processes could meet wider sustainable development aims Public participation could help ensure costs are minimised and opportunities are built on