



An Inventory of Adaptation to climate change
in the UK: challenges and findings

E.L. Tompkins, E. Boyd, S.A. Nicholson-Cole, K. Weatherhead,
N.W. Arnell, W.N. Adger

July 2009

An Inventory of Adaptation to climate change in the UK: challenges and findings

E.L. Tompkins, E. Boyd, S.A. Nicholson-Cole, K.Weatherhead, N.W Arnell,
W.N. Adger

Tyndall Working Paper 135, July 2009

Please note that Tyndall working papers are "work in progress". Whilst they are commented on by Tyndall researchers, they have not been subject to a full peer review. The accuracy of this work and the conclusions reached are the responsibility of the author(s) alone and not the Tyndall Centre.

An Inventory of Adaptation to climate change in the UK: challenges and findings

A report submitted to Defra as part of the Climate Change Impacts and Adaptation Cross-Regional Research Programme

E.L. Tompkins^{1,3}, E. Boyd¹, S.A. Nicholson-Cole¹, K.Weatherhead^{1,2}, N.W Arnell^{1,3},
W.N. Adger¹

¹ Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, Norwich, NR4 7TJ

² Cranfield Institute of Water and Environment, Cranfield University, Silsoe, Bedford, MK45 4DT

³ Department of Geography, University of Southampton, Southampton, SO17 1BJ

Abstract

Climate change science has been promoting adaptation measures for some years. The message has been that the climate is changing and people need to be prepared. However, while there has been an increasing investment in the 'science of adaptation', there has been less, if any, attention paid to the 'practice of adaptation', i.e. is adaptation occurring, and if so, how, where and why? There is now a clear demand from policy makers to answer these questions and specifically to answer them with relation to actions in the UK.

The objective of the DEFRA-funded project 'Linking adaptation research and practice', is to develop a systematic categorisation of observed adaptation in the UK in both the private and the public sectors. There are two outputs from this project:

- i) An inventory of examples of adaptation in practice in four sectors in the UK, in the form of an Excel spreadsheet
- ii) This report, which describes the process of cataloguing the examples and interpreting the data.

The inventory is a compilation of some adaptation actions that have occurred in the UK to date. It includes examples of adaptation to climate change in the public and private sectors, as well as voluntary and community groups, NGOs, other associations and networks (including, for example, trade associations) and individuals. The data presented in the inventory were collected primarily from academic literature and secondary reports that were identified through consultation with key experts in four sectors: water (supply / flood management), construction, rural land-use (biodiversity and conservation / agriculture and forestry) and transport. The inventory does not present an exhaustive collection of all the adaptations that are taking place across the UK, but it illustrates a range of different kinds of adaptation.

While developing the inventory, it became clear that there were a number of practical and intellectual challenges in designing and collating such an inventory. The key challenge involved identifying and then categorising the data using an appropriate organising principle with clear criteria. The criteria used are as follows:

- Name of institution and brief details
- Adaptation outputs and details of outputs
- Overall summary
- Classification of adaptation (implementing adaptation actions or building adaptive capacity)
- Characteristics of adaptation (how adaptation is happening in the institution, i.e. policy, organisational or behavioural change)
- Purposefulness of adaptation (whether the adaptation is planned or unplanned)
- Triggers and drivers (the reasons why adaptation is happening)
- Administrative and management scale (i.e. the level at which adaptation is happening: international, European (EU), national, devolved administrations, regional, local, individual)
- Geographic location of adaptation
- Size of institution
- Ownership of the institution (i.e. Public, private or other)
- Source of information

The organising principle adopted was the institutional analysis and development framework which suggests that actions are often shaped by social and physical institutions, in the form of regulations and laws, physical structures and people, and codes of behaviour. This conceptual framework is discussed in the report.

A second challenge involved the process of defining adaptation. Adaptation can mean taking any action to prepare for climate change which is intentional or accidental. This broad definition can then include any action taken by anyone. To make this definition operational, we adopted the UKCIP two-way categorisation of adaptation. On re-visiting this definition on completion of the project, it was found to be very fitting for the nature of adaptations in practice that we have come across and presented in the inventory accompanying the report.

Another challenge came in drawing conclusions across sectors. It is difficult to compare the sectors owing to the nature of the inventory which is neither exhaustive nor generalisable. The inventory shows that there are a range of adaptations taking place in the UK across sectors and institutions in many different ways. Within each sector that we investigated, adaptation is clearly happening yet each sector is at an 'early stage', although the examples collected reveal some general patterns. There are few examples of practical actions being implemented; most examples, reflect a building of adaptive capacity. This appears to be happening through recruitment of individuals, establishing thinking groups, or setting up task forces to think through the issues associated with climate change. There are however, also some policy changes and laws being implemented which will affect adaptation possibilities in the future. The majority of the adaptations identified are occurring in the public sector. As yet, there is little evidence of behavioural change in either the public or private sectors. Most of the examples are occurring at the national scale, in the devolved administrations and at the regional scale with few examples at local levels.

Compiling the inventory has highlighted the difficulty of judging which actions can be classified as 'climate change adaptations' and of these which are really planned as adaptations to climate change. By this we mean that it is difficult to identify which adaptations are taking place as a response to weather related (rather than risk factors) and of these, which are in response to expected future climate change. There are two clear difficulties. The first relates to the difficulty of identifying drivers of change and judging which actions can be classified as adaptations specifically relating to climate change impacts as opposed to non-climate related impacts, such as the impacts of development intervention on biodiversity. The second relates to the timing of the adaptation, i.e. is it a deliberate response to an impact or is its timing coincidental. There are many drivers of adaptation related to weather impacts (such as flooding) or climate change itself, however these are often of minor influence in comparison to others such as: general risk management, other government policy initiatives not related to climate change and financial cost-saving behaviour. There appear to be very few, if any adaptations that have been undertaken solely in response to expected climate

change. This is in clear contrast to reported mitigation actions, some of which would be unnecessary or even undesirable other than for the climate change related threats, for example, carbon sequestration and the rapid move to renewable energy.

There is a mixture of planned and unplanned adaptation taking place. More of the examples that we came across were planned and deliberately being carried out in response to the impacts of climate change and the need to adapt. Although it should be remembered that this classification of 'planned' and unplanned' in the inventory reflects our subjective judgement based on secondary data.

We can conclude that Government needs to be aware that every action it takes could generate adaptive action that may or may not produce adaptations that are beneficial. On some occasions climate change is potentially being used to support an action that is desired for other reasons, again not all of these are generating adaptation benefits. Relying on climate change to act as a trigger for change in the private and public sector is not advisable, as institutions of all types seem to be driven by other pressures and drivers. We suggest that the importance of climate change adaptation needs to be built into many different Directives and strategies, and incorporated into existing networks and partnerships such as those initiated by UKCIP. Since most current adaptations are justified on co-benefits and/or are 'no regret' options, this should be remembered when developing new governmental policies and strategies that do not relate to climate change.

Contents

	Page
Executive Summary	1
Acknowledgements	5
1. Introduction	9
1.1 Statement of problem	9
1.2 Objective	11
1.3 Research framework	11
1.3.1 Defining adaptation	11
1.3.2 Introduction to the inventory	14
1.3.2.1 <i>Conceptual framework used</i>	14
1.3.2.2 <i>Sources of data</i>	16
1.3.2.3 <i>Methodological issues</i>	17
1.3.2.4 <i>How will the inventory be used?</i>	17
1.3.3 Choice of sectors	18
1.3.3.1 <i>Water(Water supply / flood management)</i>	18
1.3.3.2 <i>Construction</i>	19
1.3.3.3 <i>Rural Land Use (Biodiversity & Conservation / Agriculture & Forestry)</i>	20
1.3.3.4 <i>Transport</i>	23
1.4 Summary	24

2. The inventory – process of creation and methodological issues	25
2.1 Design and construction of the inventory	30
2.2 Challenges of categorisation	31
2.2.1 Classification of adaptation	31
2.2.2 Characteristics of adaptation	33
2.2.3 Purposefulness of adaptation	34
2.2.4 Triggers or drivers of adaptation	34
2.2.5 Scale – Administrative or management, and geographical scale	36
2.3 Overlap between sectors	37
2.4 Information and data access issues	
2.5 Summary	
	38
	38
3. Data section	46
3.1 Non-sector specific	46
3.2 Water	54
3.2.1 Water supply	63
3.2.2 Flood management	73
3.3 Construction	73
3.4 Rural land use	79
3.4.1 Biodiversity & Conservation	85
3.4.2 Agriculture & Forestry	90
3.5 Transport	
3.6 Summary	

	91
	91
4. Understanding adaptation in practice in the UK	92
4.1 Introduction	92
4.2 What type of adaptation is taking place?	93
4.2.1 How is it occurring	94
4.2.2 Is it planned or unplanned?	95
4.3 Where are the adaptations occurring?	95
4.3.1 Institutions	97
4.3.2. Scale and location	99
4.4 What is driving adaptation?	100
4.5 Re-visiting our definition of adaptation	
4.6 Concluding remarks	
	102
	112
5. References	
6. Annex	

1. Introduction

1.1 Statement of problem

Since the Kyoto Protocol to the United Nations Framework Convention (UNFCCC) was agreed in 1997, the UK has been moving ahead and experimenting with innovative policies to reduce greenhouse gas emissions. The degree to which other nations buy-in to greenhouse gas emissions reduction will dictate how successful such innovations are in reducing the impacts of climate change. Irrespective of buy-in by other nations, any emissions reductions today will only generate climate benefits two or three decades hence due to the life of greenhouse gases in the atmosphere. Irrespective of our behaviour today we will continue to experience climate change over the next couple of decades.

Climate modelling work by the UK Climate Impacts Programme (UKCIP), the Tyndall Centre for Climate Change Research, DEFRA and the Hadley Centre are consistently showing that the climate in the UK will change over the next 100 years. Specifically, the UK climate will become warmer, high summer temperatures will become more frequent, winters will become wetter and summers drier, extreme sea levels will be experienced more frequently and the mean sea level will continue to rise around the UK (UKCIP, 2003). The impacts of this climatic change are variable across regions and sectors. Therefore, many of the regional administrations and sectors in the UK, in conjunction with UKCIP, have undertaken reviews to assess the specific impacts. See, for example, Expert Group on Climate Change and Health in the UK (2001), Kerr & McLeod (2001), Hulme *et al.* (2002) and Downing *et al.* (2003). By way of example, in the East of England Climate Change Impacts Scoping Report (East of England Regional Assembly, 2004), conducted in association with UKCIP, it is recognised that in the eastern part of England:

- Climate change will create opportunities as well as threats, particularly in the area of tourism and environmental technologies that deal with the impacts of climate change.
- Business activity will be significantly affected by changes in climate, through changes in customer demand, sector vulnerabilities, physical impacts, insurance coverage, environmental legislation and working conditions and increased flood risk, and water resources issues.
- Coastal areas are also vulnerable to sea level rise and the additional flood risk.

As the science of climate change has improved and more administrative regions have understood the likely impacts of climate change, there have been calls for answers to the question: what next? How do we prepare for and adapt to these changes. Technical understanding of adaptation to climate change is in its 'infancy' (Defra, 2004a). However, an ever-increasing number of countries and organisations are gathering information or taking actions to adapt to climate change impacts, both real and perceived. The UK Government and devolved administrations are taking a lead in preparing for the effects of climate change¹ - UK policy makers have already undertaken adaptation measures, such as the creation of the UK Climate Impacts Programme (UKCIP). The UK Government also highlights adaptation to climate change as a key issue in its new Sustainable Development Strategy (Defra, 2005a) and is preparing a national adaptation policy framework. A national consultation process, ongoing at present, aims to develop this framework.

At the same time scholars are focused on a range of adaptation questions including who and what adapts to climate change, how they adapt, the limits to adaptation, and what methods exist to evaluate adaptation. It is now clear that adaptation can be simple (such as carrying an umbrella when it is likely to rain) or a multi-faceted complex activity (such as planning to supply water to London over 50 year periods when there is enormous uncertainty about the likelihood of an action).

¹ These are outlined in the UK Climate Change Programme – currently under review by Defra.

Despite the academic and to some degree, technical understanding of adaptation to climate change, there is little evidence of whether, and to what extent, adaptation is happening. There is now a clear demand from policy makers to understand where, how and why adaptation is taking place in practice and what adaptation policies and other measures currently exist sectorally and regionally in the UK. This report aims to respond to this demand, and thereby to inform the UK adaptation strategy.

1.2 Objective

The objective of this project is to develop a systematic categorisation of observed adaptation in the UK in both the private and the public sectors. There are two outputs from this project:

- i) An inventory of examples of adaptation in practice in four sectors in the UK,
- ii) This report - describing the process of cataloguing the examples and interpreting the data.

The inventory is in the form of an Excel spreadsheet which is described in detail in sections 2 and 3. The inventory supplements an existing list of adaptations currently maintained by the UKCIP. This report describes the method used to structure the inventory (and the theory that underpins it), the process of selecting the sectors, issues associated with the collation and compilation of examples for the inventory, our key findings and a discussion of these.

1.3 Research framework

1.3.1 Defining adaptation

It would seem a simple task to define adaptation. The Oxford English Dictionary simply explains adaptation as “The action or process of adapting, fitting, or suiting one thing to another”. In terms of developing an inventory of adaptation in practice it would seem that all we have to do is find examples of individuals, businesses or government adapting, fitting, or suiting their lives, organisations or behaviour to climate changes. It

seems easy to identify an adaptation where the adaptation is obvious, for example, a company that buys fans to cool its workers in summer; or where a government decides to set up a new climate change discussion forum. These are deliberate actions by groups to anticipate climate change impacts. Less obvious, and hence less easy to identify are the actions that are not deliberate, such as an individual, who for no particular reason, and definitely not because of a knowledge or awareness of climate change decides to relocate to an area less likely to experience flooding. The motivation for the action is not to adapt, yet the outcome of the action is an effective adaptation avoiding climate change impacts. How should we categorise this type of adaptation? Clearly the individual in question is changing their behaviour, but if they are not doing this deliberately to adapt to climate change is it adaptation, i.e. does motivation matter in judging whether an action is an adaptation to climate change? This is just the first of many problems we experienced in defining the boundaries around the action of adaptation.

After much work on this inventory, we are left with the realisation that adaptation is as broad or as limited as the definer chooses. It can include both deliberate actions and unknowing actions; it can include actions taken in anticipation of or in response to a stimuli (that can be a climate change impact or the acquisition of climate change knowledge) and it will not necessarily be beneficial (not all adaptations - deliberate or accidental) will generate benefits, for example, new soil management policies could leach nutrients from soil organic matter, yet they are still adaptation). This wide all-encompassing definition of adaptation is used so that the inventory can reflect all the myriad changes that are currently occurring in the UK.

Within this broad definition, adaptation can include a range of actions, and these can, in general, be grouped into two activities:

- Building adaptive capacity
- Implementing adaptation action

Adaptation can manifest as either building adaptive capacity (another multi-dimensional term), by which we mean increasing the ability of an individual or group to implement adaptation actions, for example by learning, reading, gathering information, and research; or adaptation can manifest as implementing adaptation actions, i.e. taking actions in response to or in advance of a stimuli, for example through building sea walls. This two part categorisation was initially developed by the UKCIP. It was felt to be more appropriate for a definition of adaptation *in practice* in comparison to the more theoretical approach taken by the Intergovernmental Panel for Climate Change (McCarthy *et al.*, 2001).

We further developed this two way classification (see Box 2.1) to consider how adaptive capacity might be built, and how adaptation actions are implemented.

Box 2.1 Proposed classification of adaptation

1. Building adaptive capacity (things that are done to encourage adaptation).

Examples of possible steps to facilitate adaptation thinking and knowledge gathering:

- Investigation/research
- Legislation (enabling)
- Direct guidance/instruction
- Increase institutional capacity to adapt
- Implementing no regrets²

2. Implementing adaptation actions (responses to actual or expected impacts of climate change)

- Manage physical hazard/change (physical resources/something to do with the environment e.g. flood embankment or irrigation)
- Alter exposure to that aspect of the environment e.g. relocate/protect properties/ reduce damage caused/change crop.

² “No regrets” refers to actions taken by companies that prepare them for climate change either unintentionally for other reasons (e.g. sustainable developments) at no additional cost, or in a manner that generates secondary benefits for them that outweigh the costs of adaptation.

- Reduce vulnerability to impact (e.g. increase wealth and ability to recover) loss still happens but can cope better/insurance
-

An example of building adaptive capacity is, for example, if Defra provides guidance for companies to take measures to adapt to climate change and creates the enabling conditions for action. An example of implementing adaptation is, for example, the Environment Agency building flood defences.

As climate change is still considered a relatively new threat, and given the lack of understanding about the science and impacts of climate change we hypothesised that most examples of adaptation in practice would be about building adaptive capacity, as this can be a pre-cursor for implementing adaptation. We found this hypothesis to be accurate.

1.3.2 Introduction to the inventory

This inventory does not present an exhaustive collection of adaptations that are taking place across the UK, but aims to illustrate a range of different kinds of adaptation. The inventory is simply a compilation of some examples of adaptation in practice that have occurred in the UK to date. It includes examples of adaptation to climate change in the public and private sectors, as well as voluntary and community groups, NGOs, other associations and networks (including, for example, trade associations) and individuals. These examples are organised according to a number of criteria, such as, the institution carrying out the adaptation, the administrative scale at which the adaptation is occurring and the geographical location of the adaptation. The design and construction of the inventory is discussed further in section two.

1.3.2.1 Conceptual framework used

How best to allocate scarce resources among competing interests has been the question that has plagued societies for millennia. Theories of public choice have been applied in various ways:

- To better understand the rules that shape society and public choice
- To explain why individuals tend not to behave 'rationally' but are bounded in their decision making by institutions and decision making costs
- To explain how people behave in complex situations in both the private and the public sector.

Out of this blend of economics and political science has emerged the 'institutional analysis and development' framework pioneered by Elinor and Vincent Ostrom at Indiana University (see Ostrom, 1990) which suggests that actions are often shaped by social institutions of various forms. This framework places emphasis on three dimensions of the institutions: the *rules or regulations* that exist, including the constitution, policies and laws; the *physical structure of the organisation*, including the organisation of people, buildings and resources; and the *behavioural norms* that emerge within the institution, including customs, traditions and 'ways of doing things'. In most institutions, a combination of the rules and laws, the organisational structure and the behavioural norms appear to accurately define the boundaries that constrain human life and activity.

Using this intellectual framework we assume that adaptations to climate change will occur in the three areas:

- The rules, policy or regulations that shape the institution - these include policy guidance, legislation and so on – they are the formal rules currently in place to guide adaptation
- The organisational structure – the way public and private sector organisations are structured to address climate change, and activities that relate to the organisational perspective, e.g. commissioning research or employing an adaptation officer.
- Codes of conduct or cultural norms within the institution – these are behavioural norms that dictate change in behaviour, embedded in and as a result of organisational activities.

An adaptation could occur in any of these areas either as building adaptive capacity or implementing adaptation action. By way of illustration, Table 1.2 provides examples of these types of adaptation.

Table 1.2 Illustrative example of adaptation in practice

	Rules or regulations	Organisational structure	Behavioural norms
Building adaptive capacity	Minister creating a new policy that all government projects had to allow 'financial headroom' for the impacts of climate change.	Creation of the UK Climate Impacts Programme	Members of the Chamber of Commerce discussing how they will cope with increased levels of flooding
Implementing adaptation	Trade association implementing policy changes that commit the industry to respond to climate change	Local architecture firm establishes technical and staff capacity in designing houses for adaptation to climate change	A farmers' cooperative is changing farming methods as a result of water logged soils.

1.3.2.2 Sources of data

The report is primarily based on a review of literature and secondary reports, identified through consultation with key experts in the sectors. Sources of data for each sector can be found summarised in section three. To be more specific, data used in the inventory includes information from:

- UKCIP: such as regional scoping studies from Wales, Scotland, and the British Islands.
- DEFRA: existing and on going studies in sectors, regions, and within constraints.
- Tyndall: publications and working papers.
- Academic literature e.g. Building research and information journal
- Government publications (e.g. by DTI, ODPM)
- Other grey material
- Company annual reports.
- Media, such as broadsheet newspapers.
- UKCIP monthly newsletter mail-shot³.

Across the UK, there are adaptation experts linked to Tyndall, UKCIP, Defra, and regional bodies. The steering committee also helped to identify who the key UK adaptation experts are and acted as 'gate keepers' providing access to valuable anecdotal evidence, contacts, unpublished reports and grey material. These experts included Dr Neil W. Adger and Dr Emma Tompkins at the Tyndall Centre for Climate Change Research, University of East Anglia; Professor Nigel Arnell at the Department of Geography, Southampton University; Dr Keith Weatherhead at the Institute of Water and Environment, Cranfield University; Chris West and Richenda Connell at UKCIP; Dr Havard Prosser, Welsh Assembly; Alistair Montgomery, Scottish Executive; Hazel

³ In April 2005 UKCIP posted a notice in their newsletter asking for examples of adaptation in the four sectors. The notice received about 10 responses. The notice read as follows: '**Adaptation in Practice**'
A group of us at the Tyndall Centre for Climate Change Research are busy compiling an inventory of examples of adaptation in practice in the UK (as part of a project funded by Defra). We are seeking examples of adaptation in the Water, Construction, Land Use (including agriculture, biodiversity conservation and forestry) and Transport sectors. Please send us any examples that you know of. These will be entered into the inventory, which will be available via UKCIP after May 2005. A report will also be produced for Defra and available in June 2005.
Please contact Emily Boyd e.boyd@uea.ac.uk

Campbell, Environment Policy Group, Department of the Environment Northern Ireland; Tim Reeder, Environment Agency; and Mike Harley, English Nature.

1.3.2.3 Methodological issues

There are limits to the type of information that a literature review can provide. Such a method cannot generate a complete inventory of adaptation in practice, largely because the information on adaptation in practice is widely distributed across the multiple sources and in many cases appears to exist principally as unpublished expert knowledge. Future studies can add to the body of examples already collated. Such a study should collect this information through direct interviews with those organisations and municipalities who are already adapting. Such a process could also be used as a capacity building exercise and linked to UKCIP. More research is also required to better explain the barriers to implementing adaptation action

1.3.2.4 How will the inventory be used?

The inventory associated with this report will be incorporated into UKCIP's already existing inventory of examples of adaptation in practice. The inventory will eventually be available to general public via a web based search tool.

The model itself has been designed to be internationally applicable, but the nature of the examples is context specific. We caution against generalising from the findings to contexts beyond the UK.

Users should also be cautious about using the inventory as a transferable learning tool. Adaptations undertaken in one sector may not be directly transferable to another sector because the nature of adaptation to climate change in each sector is so specific. There is scope for making comparisons between the sectors, but it is not sensible to make detailed sectoral comparisons or generalisations based on this inventory.

1.3.3 Choice of sectors

Through a process of discussion and deliberation, the project steering committee⁴ agreed upon a potential list of sectors. The sectors were identified based on their importance to the UK, hence initial thought was given to the WEHAB+ sectors identified in Johannesburg at the World Summit on Sustainable Development in 2002⁵. The initial list included ten sectors: (1) water, (2) health, (3) construction and planning, (4) financial services, (5) security, (6) energy, (7) agriculture, (8) biodiversity, (9) transport, and (10) tourism. Sectors were then selected on the basis of the following criteria:

- Preliminary evidence of adaptation occurring/likelihood of adaptation
- Interest by DEFRA being undertaken
- Likely availability of information
- Experience of the project steering committee in these areas.

Finally, four sectors were selected, including: water, construction, rural land use, and transport. Further explanation of sector selection is outlined below.

1.3.3.1 Water (*Water supply / flood management*)

The UK water sector is likely to be highly impacted by climate change. There is agreement among scientists that climate change is the most significant factor affecting the availability of water resources in the mid-to-long term. UKCIP 2002 Scenarios⁶ suggest that winters may become wetter and summers drier. Hulme *et al* (2002) show in their climate change scenarios that annual river flows could fall by the 2020s with significant reduction in summer flows. Arnell and Reynard (1996) suggest that progressive change in river flows over the next few decades would be noticeable on a decade-to-decade basis. The UKCIP regional reports show that water shortages vary throughout the UK and are a serious threat to seven out of 12 regions in the UK,

⁴ The project was overseen by a steering committee consisting of 8 representatives from the Tyndall Centre for Climate Change Research (including: School of Environmental Sciences at UEA, Geography Department at Southampton University and Institute of Water and Environment at Cranfield), UKCIP and Defra Global Atmospheres Division.

⁵ For more information see: www.johannesburgsummit.org/html/documents/wehab_papers.html

⁶ Hulme *et al* (2002) Climate Change Scenarios for the United Kingdom: The UKCIP02 Report describes and presents four possible climate futures for the UK.

including East of England, East Midlands, North East, South East, South West, Wales and West Midlands (for more information see: <http://www.ukcip.org.uk/resources/location/location.asp>). Already there exist a number of examples of adaptation, for instance, water companies have examples of supply issues and adaptations and national, regional and local public bodies are responding to the problems increased precipitation and sea level rise. Specifically the likely impacts on the water sector in the UK are:

- increased water demand
- increased droughts leading to worsening water supply problems in parts of the UK,
- increased flooding risk in many lowland areas, due to more frequent river flooding and storm surges.

1.3.3.2 Construction

Climate change is likely to affect many aspects of the built environment in future, and this sector will need to respond to an inevitable degree of climate change (Steemers 2003a). The impacts of climate change will depend on the design, construction, use and planning for the location of buildings and settlements (Liso *et al.* 2003, Hasegawa 2004). It poses a significant risk because it implies not only warmer weather, but also more extreme weather events, such as storms, droughts and heat waves (White 2004). Changes in rainfall, storm frequency, wind speeds and a rise in temperature for example, will have impacts on water supply, coastal and inland flooding, drainage systems, subsistence, the structural integrity of buildings (e.g. roofs and foundations) and internal environments (see Graves & Phillipson 2000). In short, the construction sector is likely to be impacted by:

- increased weather variability and flooding;
- damage to premises and properties in flood-plain and coastal areas; and
- problems with subsidence following extensive dry spells.

Incorporating adaptation considerations into the planning and construction of new and existing built environments will help to avoid climate-related damages and costs in the longer-term, when climate change impacts are likely to be felt more intensely. Adaptive behaviour will, to a large extent, determine the nature and scale of these impacts (Hertin & Berkhout 2003). The ways in which buildings are planned for, designed and constructed will have to undergo changes over coming years in order to ensure their longevity. Considering the massive expansion of housing stock proposed for coming years, e.g. the Thames gateway⁷, adaptation considerations may be crucial to the longevity of such developments. In the background literature, there is some evidence to suggest that changes are starting to happen within the planning and construction sector, but that moves towards climate change adaptation are at a very early stage (see also Liso *et al.* 2003).

1.3.3.3 Rural Land Use (Biodiversity & Conservation / Agriculture & Forestry)

Climate change is likely to have substantial impacts on the UK's land use sector. This includes changes to biodiversity conservation, agriculture and forests. These are all intrinsically linked at the landscape level. The big issues relating to rural land use and climate change in the UK are lowland and upland agriculture, water (flooding, quality, and resources) and biodiversity (Defra, 2005b).

The impacts of climate change on the rural land use sector are likely to be:

- mixed impacts on crops production – some beneficial and others detrimental
- threats to some wildlife, species and habitats and opportunities for others
- the range and distribution of plants and wildlife is likely to change.

Biodiversity & Conservation

Climate change will pose a significant challenge to this sector. Climate change coupled with fragmentation of landscape threatens many of the world's ecosystems. Under the 2002 UKCIP Scenarios, biodiversity will be severely impacted in the UK (Hulme *et al.*,

⁷ The Thames Gateway region has been noted as being one of the most vulnerable to sea level rise, increased flood risk and water resources issues (East of England Regional Assembly (2004) in association with UKCIP).

2002). Already species are responding to climate change as for example butterflies are emerging earlier and flying longer and plants are flowering earlier (English Nature, 2005). UK biodiversity policy and site management responses are increasingly encouraged to factor in climate change. Yet, whether organisations, local authorities, farmer enterprises or private individuals are engaging in “re-connecting” to the countryside such as securing more effective targeting of agri-environment schemes is another issue. Dockerty *et al* (2003) also caution that management strategies for individual sites or networks of reserves might need to be reconsidered in order to prevent the loss of valuable species and habitats.

Agriculture & Forestry

Across Europe warming as a result of climate change is expected to lead to northward expansion of suitable cropping areas and a reduction of the growing period of determinant crops (e.g. cereals), but an increase for indeterminate crops (e.g. root crops) (Oleson and Bindi, 2002). Increasing CO₂ concentrations are expected to directly enhance plant productivity and also increase resource use efficiencies. Thus, policies to support adaptation and mitigation to climate change will need to be closely linked to the development of agri-environmental schemes in the EU common agricultural policy.

The impacts of higher mean temperature, increased precipitation and storms and sea level rise all have serious implications for UK’s agricultural sector. There is likely to be a mixture of effects on crop production; some will be beneficial, such as reduced frost damage and accelerated growth as a result of warmer weather. Others are likely to be detrimental for example, spread of crop diseases and increased water stress reducing crop yields (Defra, 2004a).

Addressing the impacts of climate change will require parallel processes at the government level, reform and development of new policies across water, flood management, agriculture, and biodiversity, and at the private level will require risk-based approaches for land management and local solutions. Rounsevell *et al.*, (1999) suggest that the use of good land management practices provides the best strategy for

adaptation to the impacts of climate change on soils. Farmers will need to carefully reconsider their management options, and land use change is likely to result from different crop selections that are more appropriate to the changing conditions. Agricultural enterprises will also need to adapt to the effect of climate change to ensure economic viability and to minimise agriculture's impact on the environment (Defra, 2005b).

Climate changes over the next 100 years are predicted to be larger and more rapid than any since the last ice-age, posing real problems for trees, woodland and forestry. Some sectors are able to adapt naturally or incrementally to a changing climate; much depends on the timescale of change within a sector. Where response times are slow, such as in forestry crop rotation, then a strategy of adaptation to climate change would appear essential. The time scale of adaptation is likely to be several decades because of the long-term nature of tree growth. Trees can take over 100 years to reach maturity, so the trees we plant now will mature in a climate that may be very different to the one in which they were planted. The predicted changes in climate may have a profound effect on our trees, which, once planted, must endure whatever climate ensues (Broadmeadow, 2000; Forestry Commission, 2005).

Kerr *et al.* (1999) suggest that there are a range of climate change impacts facing the forestry sector:

- Temperature is probably the most important variable to affect forest growth (the variability of summer/winter temperatures being of greater importance than average temperature).
- Changes in rainfall and the consequent soil moisture regime may be of importance, and waterlogged ground may become more common particularly in autumn and winter.
- Excess wind has a major negative impact on forests while higher atmospheric carbon dioxide concentrations are likely to improve growth rates. The most serious risk to forestry from climate change appears to be the possibility of more extensive wind-storms leading to more blow-down and limitation of tree height.

- Other negative impacts to forestry that have been suggested include insect damage and associated factors if temperature gain exceeds particular thresholds.
- The commercial sector may benefit from the possibility of using a wider range of species, which could generate more valuable products and increased growth rate, resulting in shortened rotation times. Non-commercial woodlands would benefit from enhanced species availability, and a wider range of broad-leaved forests would be better able to supply appropriate wood for local craft industries (potential to enhance the viability of rural communities).

1.3.3.4 Transport

Climate change will have significant impact on the transport sector in the UK. Already the impacts of climate change are starting to be recognised in this sector. The UK's changing climate has important consequences for transport. The transport sector is likely to be affected by the impacts of climate change in a number of ways: increased flooding on rail and road networks during winter; the threat of damage to rail tracks and road surfaces in extreme weather conditions; in the long term, potential damage to earthworks for embankments and bridges. The Department for Transport (2004) notes that the following issues are most critical to the transport industry:

- Increased flooding during winter, affecting all modes of transport. The risks being greatest in flood plains and where urban drains are overloaded.
- Some coastal stretches may be at risk of inundation by the sea during periods of particularly high winds when coupled with the highest tides. This will be of particular concern for coastal railways, e.g. in Wales and parts of South West England.
- More extreme heat during summer could lead to heat exhaustion for vulnerable passengers on the London Underground, particularly when subject to delays.
- Sudden structural failures are extremely rare, but, if no action were taken, the risk of such failures could increase due to soil saturation and the scouring action of rain/high rivers.
- Difficult driving conditions due to snow and ice would decrease but the number of days when driving was difficult due to rain, leaves and storms would increase.
- Even though the number of days of frost and snow will decrease, it will be important to retain experience in dealing with sub-zero temperatures.

All of these potential impacts on the transport sector necessitate adaptation. The DfT emphasises that to respond to these changes, infrastructure will need to be built and maintained to withstand hotter temperatures, worse storms, more intense rain, and

higher sea levels. Contingency plans will also have to change in expectation that they will be needed more often and for more extreme impacts.

The inventory also includes a section which presents non-sector specific examples of adaptation in practice. These examples are applicable across sectors and have been presented together in a section of their own to avoid duplication in each part of the inventory. Section three also includes a section reviewing this section of the inventory.

1.4 Summary

Section one explains the objectives of this report and introduces the inventory. It describes the conceptual framework used, methods adopted and sources of data. It also outlines the choice of sectors and explains why these are relevant for adaptation to climate change. The report now turns to section two and the design and construction of the inventory.

2. The inventory – process of creation and methodological issues

Section two addresses the design and construction of the inventory, how to find your way around the inventory and the problems of categorisation encountered in developing the inventory.

2.1 Design and construction of the inventory

This section outlines the design and construction of the inventory starting with an introduction to its organisation. The inventory comprises nine worksheets in an Excel workbook. The worksheets (in order of presentation within the inventory) provide the following information:

1. Introduction to this inventory
2. Inventory map
3. Non-sector specific
4. Water supply
5. Flood management
6. Construction
7. Biodiversity & Conservation
8. Agriculture and Forestry
9. Transport

Each worksheet is organised according to row and column headings which reflect the type of organisation (row) and the organising criteria (columns).

The columns contain the criteria by which we organised the examples (briefly outlined in Table 2.1). Many of the criteria used relate to the nature of the institution taking the action. For example, the administrative and management scale and geographical location at which the adaptation occurs is considered. The administrative and

management scale identifies where in the organisational hierarchy the adaptation occurs, and the geographical scale considers where in the country the adaptation occurs.

The column headings are presented in the inventory according to their perceived relevance to potential users of the inventory. For example the first five columns summarise the name of the institution, what it does, its adaptation outputs, details of these outputs along with a fuller summary. The rest of the criteria offer more specific features of the adaptation examples, for example, whether the adaptation is planned or unplanned, its geographic location and so on. Section 2.3 explains the challenges involved in selecting and using these criteria.

Table 2.1 Inventory criteria explained

Column headings	Details
Name of institution	The name of the public or private organisation from which the example is drawn.
Brief details of institution	Any necessary details that explain in brief what the institution or organisation does or is
Adaptation outputs	This describes the outputs relating to the adaptation (e.g. report, guideline, project, policy)
Details of output	(e.g. name of publication)
Summary	This provides a more detailed description of the example
Classification of adaptation	Two characteristics are differentiated: implementing adaptation or building adaptive capacity
Characteristics of adaptation	How is adaptation happening in the institution (i.e. policy, organisational or behavioural change)
Purposefulness of adaptation	This identifies if the adaptation is planned or unplanned
Triggers and Drivers	The reasons why adaptation is occurring
Administrative and management scale	i.e. the level at which adaptation is happening: international, European (EU), national, devolved administrations, regional, local, individual)
Geographic location of adaptation	Where the adaptation action is taking place e.g. East Anglia
Size	For example, the number of people working for an organisation/firm or the number of businesses
Ownership of the institution	The ownership structure of the organisation (e.g. public/private/other)
Source of information	Links to documents or further information

The row headings describe the type of institution adapting (defined in Table 2.2) and encompass 'public', 'private' and 'other'. **Table 2.2 Definition of row headings in the inventory**

<i>Institution</i>	<i>Definitions</i>	<i>Source</i>
Public		
Government Ministries and Departments	The main role of government departments and their agencies is to implement government policy and to advise ministers.	Directgov (UK) http://www.direct.gov.uk (Accessed 17.05.05)
Government agencies	Executive Agencies are part of The Crown. They do not usually have their own legal identity, but operate under powers that are delegated from Ministers and Departments.	http://www.direct.gov.uk
Government programmes	Government funded programmes such as the UKCIP	
Government funded research institutes	Government funded research institutes such as Tyndall Centre for Climate Change Research	
Regional government agencies/government offices for the regions	Decentralised agencies and offices play an increasingly pivotal role at the heart of Government. Government Offices' have responsibility for delivering policy in the regions and advise Departments on successful implementation strategies at regional and local level. ⁸	http://www.direct.gov.uk
Devolved administrations	Scotland, Wales and various English regions have or will have local government	http://www.direct.gov.uk
Local authorities	Local authorities exercise power within statutory restrictions. The main link between local authorities and central government in England is the Office of the Deputy Prime Minister. In Scotland, Wales and Northern Ireland, local authorities now deal mainly with the devolved Parliament and Assemblies.	http://www.direct.gov.uk
Public-private partnerships (PPP)	Any collaboration between public bodies, such as local authorities or central government, and private companies tends to be referred to a public-private partnership (PPP).	BBCNewsonline http://news.bbc.co.uk/1/hi/uk/1518523.stm Accessed 17.05.05)
Private		
	Includes businesses, partnerships, and enterprises.	
Other		
Voluntary, community and NGO's	Done, given, or acting of one's own free will; working or done without payment.	The Oxford English Dictionary http://www.askoxford.com/?view=uk Accessed 17.05.05)
Associations and Networks (e.g. trade associations)	Associations are membership organizations; Networks are the essential means of linking one group of agents to others whom they affect.	Danson and Whittam (1999) Regional Governance, Institutions and Development. Regional Research Institute, West

⁸ Since May 2002 the government offices have been part of the Office of the Deputy Prime Minister (ODPM). The ODPM has taken on new responsibilities for housing, planning, regeneration and regional and local services from the Department for Transport, Local Government and the Regions (DTLR) which has been split up.

		Virginia University. (http://www.rri.wvu.edu/WebBook/Danson/glossaryterms.htm Accessed 17.05.05)
Individual	A single human being or item as distinct from a group.	The Oxford English Dictionary (http://www.askoxford.com/?view=uk Accessed 20.05.05)

A map of the inventory is presented in Figure 2.1. It demonstrates the details of the column and row headings used in the inventory.

By categorising the inventory by type of institution (row heading) and by type of adaptation (column heading) users should be able to search for specific types of examples. For example, if a user is looking for adaptations taking place at a particular administrative or management scale or if they are looking for examples specifically in the private sector they can do so.

Figure 2.1 Map of the inventory

Name of sector													
Name of institution	Brief details of institution (what it does)	Outputs relating to the adaptation (e.g. report, programme)	Details of output (e.g. name of publication)	Summary	Classification of adaptation (building adaptive capacity or implementing adaptation)	Characteristics of adaptation (how is adaptation happening in the institution i.e. policy, organizational or behavioural change)	Purposefulness of adaptation (i.e. planned or unplanned adaptation to climate change)	Triggers and drivers (why is the adaptation occurring?)	Administrative or management scale of adaptation (i.e. the level at which adaptation is happening: international, European (EU), national, devolved administrations, regional, local, individual)	Geographic location of adaptation example (e.g. East Anglia)	Size of institution (e.g. number of employees)	Ownership of the institution (i.e. Public / Private / Other)	Source of information (links to documents / further information)
PUBLIC													
Government Ministries and Departments													
Government agencies													
Government programmes													
Government funded research institutes / programmes													
Regional government agencies													
Devolved administrations													
Local authorities													
Public-private partnerships													
PRIVATE													
OTHER													
Voluntary, community and NGO's													
Associations and networks													
Individuals													

2.2 Challenges of categorisation

This section reflects on the challenges encountered in identifying, defining and using the inventory criteria. The problems encountered in the design and development of the inventory generally included:

- Problems of categorisation and problems of extending this;
- Overlap between sectors (e.g. blurred lines between sectors) (see section 2.3)
- Information access issues, e.g. Lack of information on the variables, such as the size of organisations and problems of accessing data (see section 2.4).

In the inventory we encountered specific problems associated with the following list of criteria:

- Classification of adaptation (difficulties in assessing the distinction between building adaptive capacity or implementing adaptation in practice despite our framework in section one).
- Characteristics of adaptation (difficulties in discerning between the way in which adaptation is happening i.e. policy, organisation, or behavioural change)
- Purposefulness of adaptation (difficulties in consistently identifying the extent to which adaptations are planned / unplanned according to climate change / or other considerations)
- Triggers and drivers (difficulty in identifying from the literature the reasons why adaptation is occurring)
- Administrative or management scale of adaptation (issues of categorising the political scale at which adaptation is occurring)
- Ownership of the adaptation (sometimes a problem of identifying whether adaptation falls into the public / private / or other sector)
- Size of institution (difficulties in identifying from the literature the number of people working for an institution)

2.2.1 Classification of adaptation

The adoption of the UKCIP classification of adaptation used in this project (building adaptive capacity and implementing adaptation actions) meant that an existing explanation of adaptation could be used. Unfortunately in practice, examples of adaptation do not always clearly fall into one classification or the other. For example, PPG 25 Planning Policy Guidance on Development and Flood Risk (Office of the Deputy Prime Minister, 2004) may be construed as implementing adaptation action because the institution (Office of the Deputy Prime Minister) is changing policy in order to drive adaptation to climate change. On the other hand, the existence of the PPG 25 reflects the building of adaptive capacity. In this instance, the policy helps organisations and individuals to adapt to climate change by providing the framework for adaptation responses, i.e. building capacity to adapt. Yet, it could be argued that it is a physical change in the law and hence an action implemented. At some prior time period knowledge must have been built such that it was deemed necessary to produce the PPG 25. Thus the final classification simply depends on the perspective from which you consider the adaptation. From an external perspective the PPG 25 might be seen as implementing adaptation through policy change. From an internal perspective the PPG 25 might be considered the output of a process of capacity building, or that the PPG 25 sets guidance for how public, private and other sectors should act to adapt to climate change.

The point in time when the adaptation is identified can also affect how it is classified, i.e. if an adaptation is identified during the phase when a group is thinking about doing something it will be categorised as 'building adaptive capacity' whereas if the adaptation is identified after an action has been taken then it will be recorded as 'implementing adaptation'. It must be remembered that the adaptations shown in the inventory reflect the situation from October 2004 – May 2005. Many of the adaptations shown in the inventory as building adaptive capacity may now have become 'implementation actions'. It must be remembered that this inventory is a static snap shot.

2.2.2 Characteristics of adaptation

As noted above, it is helpful to use the institutional analysis and development framework to think about the areas within an institution where adaptation occurs in practice, i.e. changes in the rules or regulations, changes in the organisational structure, or changes in behaviour. However, in practice there are several challenges associated with characterising examples of adaptation in this way. One relates to the issue of when the adaptation was identified (at the thinking stage, the ideas stage, the implementation stage). The other challenge relates to the subjective nature of the classification process. There were no pre-defined criteria to assist with classification, so each was undertaken on a subjective basis. For example, The National Trust has invested in making the Education Centre at Brancaster, Norfolk, flood-proof. This is an example of planned adaptation and reflects a physical response by changing the building structure; however it also possibly reflects a behavioural change within the organisation (i.e. prioritising adaptation to climate change).

In instances like this, we have sought to go as far back in the decision making process as possible to show where we have identified the adaptation. Again, this highlights yet another difficulty in categorising adaptation. Examples can be found where an adaptation action has occurred, e.g. a new law passed such as PPG 25. It is possible to trace the actions and decisions that underpinned this action. Clearly there was thought given to the decision, people would have talked about the issue, research would have been undertaken. At some point there must have been an action or event that started this process. However, we will never be able to identify what that one or series of events were. We have no information on the process leading up to the implementing adaptation, thus we cannot classify this as both building adaptive capacity and implementing adaptation. Thus, in the case of the National Trust Education Centre at Brancaster, Norfolk, we have chosen to classify the example as implementing adaptation because of the point at which we encountered the example. If more information was available that would indicate building adaptive capacity we would have included this.

A third challenge relates to the lack of data or a paper-trail that enables a researcher to identify where and when the decision was made to adapt. For example, in the National Trust example above, it is difficult still to discern from literature whether this reflects a behavioural change embedded in or as a result of the organisational activities. This is because the decision making processes are often not documented i.e. they are not published or transparent.

2.2.3 Purposefulness of adaptation

The inventory categorises the purposefulness of adaptation, i.e. whether implementation of adaptation or building adaptive capacity is planned or unplanned. A planned adaptation can be thought of as a deliberate or conscious response to climate change. This distinction in the inventory helps to understand what drives adaptation in practice. See Table 2 for some examples.

Table 2.1 Purposefulness of adaptation

	Implementing adaptation	Building adaptive capacity
Planned (deliberate)	Sea Defences	PPG25 (flood plan)
Unplanned (non deliberate)	Thames Barrier ⁹	Environmental Management Strategies in a company

- **Planned implementing adaptation:** An action that is planned as response to the impacts of climate change, based on e.g. knowledge or experience of impacts.
- **Planned building adaptive capacity:** This could be guidance or regulations that are planned and assist building capacity to adapt to climate change impacts.
- **Unplanned implementing adaptation:** An action that is an unintentional adaptation to climate change impacts, but that has potential adaptation co-benefits.

⁹ This refers to the existing barrier, designed before climate-induced sea level rise was an issue. The discussions now on raising the barrier are very much a planned adaptation.

- **Unplanned building adaptive capacity:** This is unplanned guidance of regulation that helps to build adaptive capacity to climate change without planning to do so.

It was often difficult to establish, based on the information which described the adaptation, whether there was purposeful planning. In many cases it was not always possible to tell clearly whether the example was planned in response to climate change or for other reasons (e.g. sustainable development measures). To overcome this problem, in the inventory, examples are only classified as planned adaptations if there is clear evidence that they are driven by the awareness of the need to adapt to climate change. We have found that much of the adaptation actually taking place in practice is unplanned. Adaptations are often closely linked to demands for corporate social responsibility and/or sustainable development initiatives. For example, water saving measures undertaken as part of a sustainable development strategy (e.g. lots of examples in the construction sector inventory) or abstraction impacts on special sites of scientific interest (e.g. Portsmouth Water).

2.2.4 Triggers or drivers of adaptation

Drivers of adaptation can be climate change related or non climate change related. We have found a large list of climate change related drivers such as flooding, extreme weather, or sea level rise or knowledge about the impacts of climate change. There are also numerous non climate change related drivers (specifically relating to unplanned adaptations) such as, sustainable development policy, environmental impact assessments, and cost savings. Often, the drivers of adaptation to climate change are also indirect. For example, while they may appear to be in response to a concern about climate change, they might actually be driven by a particular policy or legislation which forces an institution to undergo some kind of adaptation.

The lack of clear explanation in the literature limits the ability to assess what has initiated an adaptation. Attribution of motivation is difficult as there are many reasons for organisations not to explain their motivations. For example a company that wants to

implement some cost-cutting measures may be able to communicate these better if it can be explained as a means to better prepare for climate change, which may not have been a factor in the decision.

We suggest that an alternative method of research into adaptation in practice, for example, based on interviews with key individuals in a certain sector / institution, would be more revealing of the drivers of adaptation.

2.2.5 Scale – Administrative or management, and geographical scale

Examples in the inventory reveal that adaptation occurs at different administrative or management scales. This criterion refers to the scale at which examples of adaptation can occur: international, European (EU), national, devolved administrations, regional, local, and individual. We decided to include this range in order to capture the diversity of administrative and management scales at which adaptation is taking place in the UK. It was difficult to decide on the nature of the scale, whether it be more reflective of political boundaries or management scale. Administrative or management scale was finally selected at the criterion as it reflects both public and private sector scales of adaptation.

Geographic scale refers to the geographic boundaries within which the adaptation occurs (e.g. Yorkshire). It was difficult to consistently locate the adaptation as opposed to the institutional location, some times these were the same and other times different. Similarly it is difficult to assign a geographic location to some adaptations, especially building adaptive capacity, as this often involved information and knowledge gathering in specific locations but may have produced more general knowledge for the organisation.

2.3 Overlap between sectors

By dividing the inventory by sector we have encountered a number of examples of adaptation that are cross-sectoral. These examples include local authority scoping studies, which incorporate a consideration of the impacts of climate change on all sectors and adaptation responses. Because of the nature of many examples a worksheet had been included in the inventory entitled 'non-sector specific examples'. Other examples overlap two sectors, for example, policies or programmes that address agriculture, biodiversity and water. A specific example which overlaps between the water and construction sectors is the Planning Policy Guidance 25: Development and Flood Risk (Office of the Deputy Prime Minister, 2004).

2.4 Information and data access issues

There are some gaps in the inventory, we are sure that there are many examples of adaptation that we have not uncovered and there are incomplete entries within the spreadsheets. Limited data and limited access to documents prevented full completion of some entries, notably in classifying the adaptation by both driver and purposefulness. The motivations for the actions are often not explicitly stated in documents. For example, the reasons why a local government adaptation activity occurs, such as local flood protection measures, might be reported in the national or local media but not reported or easily found in local authority reports or web pages.

In terms of identifying examples we have found that primary data collection is a more successful method for highlighting data sources and for identifying actual examples than secondary data. Where primary data were collected, through telephone or face to face interviews, (it should be noted that primary data collection was outside the original remit of this project, which was to focus on literature) with individuals working on adaptation we have been directed to relevant sources of information, which we would otherwise have missed in the literature. We realise that there may be a lot more adaptation occurring in practice than is reflected in the inventory, because these are not published

or reported. UKCIP have done a lot of work to assist us and to bring information about adaptation at the local level to light.

2.5 Summary

Section two has summarised the design and construction of the inventory, and outlined the challenges faced during the categorisation of examples, specifically classification, characteristics, purposefulness, triggers and drivers, and scale of adaptations in practice. It has also discussed knowledge transfer, integration, and information issues. Section three goes on to describe the data presented in the inventory.

3. Data Section

Section three describes the data in the inventory of adaptations by sector. Examples of adaptations in four sectors are considered: the water sector (water supply and inland and coastal flood management); the construction sector; the rural land-use sector (biodiversity / conservation and agriculture / forestry); the transport sector. There is also consideration of general adaptations that do not fall within one sector, we refer to this general group as 'non-sector specific' adaptations. Within each sector, the adaptation is described in terms of: the institutional range of adaptations; adaptation outputs; classification of adaptation; characteristics of adaptations; the purposefulness of adaptations; scale of adaptations and drivers of adaptations. The section draws on examples from the inventory. It is suggested that the reader refer to the inventory in conjunction with reading this section. Once again, these examples are not necessarily representative of adaptation in practice across the UK, they are simply reflective of the examples that we have come across over the duration of this project and based on the literature available.

3.1 Non-sector specific

Introduction

The non-sector specific inventory encompasses all examples of adaptation which are cross-sectorally relevant. In looking for adaptations in this area we found mostly adaptations occurring in the public sector. Adaptation is happening in other types of institutions (specifically associations and networks) but no general examples were found in the private sector. A wide variety of outputs are included as examples in the inventory indicating that much cross-sectoral activity is occurring in the field of climate change adaptation, for example, reports, strategy and policy development at various scales, toolkits, etc.

Within this non-sector specific group there is only one example of adaptation being implemented in practice, all others are of building adaptive capacity, which may indicate that progress on adaptation is still at an early or scoping stage. Most of the examples of adaptation are of organisational-related adaptations, closely followed by policy activities. However, there is little evidence of behavioural change. Most of the examples are occurring at national scale, in the devolved administrations and at the regional scale with fewer examples at local levels. Most non-sector specific adaptation appears to be planned with climate change adaptation in mind, yet there are many drivers of the adaptations, though mostly related to climate change itself. The following sections elaborate on this brief overview of the content of the inventory.

Institutional range of adaptations

Some of the institutions adapting in this sector are presented in Box 3.1.

Box 3.1 Examples of institutions adapting to climate change in the non-sector specific inventory of examples

Public

- Government Ministries and Departments, e.g., ODPM, Defra, and the former DETR
- Government Agencies, e.g., The Environment Agency
- Government programmes, e.g., UKCIP
- Government Funded Research Institutes / Programmes, e.g., Hadley Centre, Tyndall Centre, and SNIFFER
- Devolved Administrations, e.g., Scottish Executive, Welsh Assembly, Department of Environment Northern Ireland
- Regional Government Agencies, e.g., Yorkshire Forward, Government Office for the Southwest, Government Office for the Southeast, East of England Regional Assembly
- Local authorities, e.g. Bristol County Council, Middlesbrough Council, Woking Borough Council, Surrey and Devon County Councils

Other

- Associations and networks, e.g., London Climate change Partnership, Cheltenham Climate Change Forum, Southwest Climate Change Impacts Partnership, Sustainability West Midlands

Most of the public sector examples are happening in Government Ministries and Departments and in Departments of the Devolved Administrations. For example, the Department for the Environment (Environment and Heritage Service), Northern Ireland, which has produced 'Guidance for public bodies on climate change impacts in Northern Ireland'. The guidance explicitly states a need to plan for adaptation to climate change,

to help avoid the worst consequences of climate change in the future. It advises how climate change will have local impacts, what can be done for mitigation and adaptation (e.g. be informed, corporate plans, coordination, leading by example), when to take action and planning for the future.

Fewer examples were found in government agencies, programmes, funded research institutes, regional agencies and local authorities. There are no examples of public-private partnerships or private sector adaptations in this part of the inventory.

Other examples of adaptation were found under associations and networks, but no examples of voluntary, community and NGO, or individual adaptations. For example, The Cheltenham Climate Change Forum set up as a working party to discuss raising the profile of the climate change agenda in the South West. The group decided to arrange a conference with a regional emphasis in partnership with the United Kingdom Climate Impacts Programme (UKCIP). The Cheltenham Climate Change Forum Steering Group was subsequently set up comprising senior representatives from private and public industry and other organisations across the region.

Adaptation outputs

There is a good variety of outputs being generated from the adaptation work occurring in these examples. There are not only reports being produced but networks and programmes are being created, one such is the UK Climate Impacts Programme (UKCIP) which supports a stakeholder group, encourages new networks, offers guidance, toolkits, models and other practical outputs for use by people and businesses interested in climate change. Although there is undoubtedly still a long way to go, the emergence and continued success of UKCIP indicates that the groups it interacts with are aware of the need to think about adaptation and they are seeking ways to ensure that climate change is included in planning and policy development in as straight forward ways as possible.

Many reports have been produced by regional organisations in association with the UK Climate Impacts Programme to assess the impacts of climate change facing the regions and to begin developing options to address the risks. In particular regional level scoping studies and follow on work have been undertaken, such as that by Yorkshire Forward, Surrey County Council, East of England Regional Assembly, the North East Assembly, and Sustainability West Midlands.

Classification of adaptations: Implementing adaptation actions and building adaptive capacity

There are no examples of implementing adaptation actions, except for the case of programmes, organisations and agencies, such as the UKCIP and the Environment Agency, which are involved in regional climate change partnerships. The EA, the leading public body for protecting and improving the environment of England and Wales, is involved in all of the regional climate change partnerships, supporting their work on promoting the need for adaptation responses. One example of the Environment Agency's work can be seen in their first national report on climate change, 'The climate is changing – time to get ready' (2005a). This report is an example of planned anticipatory adaptation, which we categorise as building adaptive capacity as it shows how the environment and quality of life in England and Wales will be affected by climate change, and highlights the need to adapt now to minimise the impacts. We judged this to be building adaptive capacity as the production of the report involved the consideration of climate change in the planning process, yet it did not result in a practical action being implemented. This adaptation is important as it led to a growth in knowledge and ability to take action at a later date.

Local and regional climate change partnerships are good examples of building adaptive capacity. See Box 3.2 for the example of the London Climate Change Partnership.

Box 3.2 Example of building adaptive capacity – The London Climate Change Partnership

The Greater London Authority established the London Climate Change Partnership to address the potential impacts of climate change on the Capital. The partnership comprises various public, private and voluntary sector organisations from across London. The partnership produced a report in 2002, in association with UKCIP to address the impacts of climate change on London.

The rest of the cross-sectoral examples in the inventory are also of building adaptive capacity. One example is the Scottish Executive (devolved government for Scotland), which commissioned research resulting in a report entitled 'Potential Adaptation Strategies for Climate Change' (Kerr and McLeod, 2001). This research aimed to

identify potential Scottish opportunities to moderate the adverse impacts of the changing climate and to realise concomitant opportunities. The study comprises information from relevant Executive Departments and Agencies and selected external organisations. It draws heavily on the work undertaken as part of the Climate Change: Scottish Implications Scoping Study (Kerr *et al.*, 1999) and the work of the UK Climate Impacts Programme (McKenzie Hedger *et al.*, 2000).

This may indicate that work on adaptation in these areas is still in its infancy and therefore more resources are being put into developing knowledge of impacts and adaptation options rather than implementing change.

Characteristics of adaptations

Out of a total of 59 examples of cross-sectoral adaptation the majority (37) were found to be organisational changes such as changes to the organisational structure (i.e. the way that public and private sector organisations are structured to address climate change), and activities that relate to the organisational perspective (e.g. commissioning research or employing an adaptation officer). 21 examples were policy-related, i.e. changes to the policy or regulations that shape the institution, such as, policy guidance or legislation. One example in this part of the inventory is behavioural (codes of conduct or cultural norms within the institution).

The vast majority of the examples are occurring in the public sector at various scales. In the regions (see the inventory row heading 'Public: Regional government agencies'), there are many examples, see Box 3.3.

Box 3.3 Yorkshire Forward as an organisational example of adaptation in practice

Yorkshire Forward is the Regional Development Agency responsible for the sustainable economic development and regeneration of the Yorkshire and Humber area. 'Warming up the region - Yorkshire and Humber Climate Change Impact Scoping Study' (2002) notes that the region's response to climate change should involve mitigation against the causes of climate change AND adaptation to the impacts and opportunities arising from it. It gives climate scenarios for the region and more detail on sea level rise and the impacts on coasts; increasing flood risks, drainage and other issues for rivers and floodplains; water resources - supply and demand; agricultural landscapes - agriculture and forestry; changing habitats - and biodiversity; industrial change - industry and commerce; the service sector. It suggests current progress and ways forward for the region regarding each of these issues.

There are also a good number of examples under the inventory row heading 'Public: Government programmes', although most of these are examples of the work of UKCIP. Because so few of the examples in this part of the inventory are concerned with implementing adaptation, it is possible that the process of delivering adaptation action is occurring more at the private sector or individual level.

Scale of adaptations

Within organisations, 24 examples of adaptation are occurring at the national scale (two examples of research projects by the Tyndall Centre for Climate Change Research, a UK Research Council funded research institution, are of both national and international relevance). 13 examples are found in the Devolved Administrations, 19 from the regions around the UK and 5 were found at the local level. No examples of individual adaptations were found.

At the local level, all the examples are of local authority adaptation activities such as Middlesborough Council's Climate Change Community Action Plan (2002) and Woking Borough Council (see Box 3.4).

Box 3.4 Woking Borough Council – local example of planned adaptation (building adaptive capacity)

Woking Borough Council aims to pool knowledge with organisations such as the Environment Agency and computer modellers to generate an accurate picture of what Woking faces in terms of flooding and temperature change, for example, i.e. the more information they have, the better equipped they will be to take action to reduce the risks threatened by climate change.

Not only are the adaptations being undertaken at different scales within the organisations, but they can be found in a variety of geographical locations around the UK. There are 23 examples of adaptation taking place from trans-UK to cities and wards, for example Woking in London (refer back to Box 3.4).

Purposefulness of adaptations

With the exception of one example, all the adaptations identified were purposeful and were implemented specifically to respond to climate change. There is one example of unplanned adaptation from the former Department for the Environment, Transport and the Regions. The example is a guide entitled 'Planning for Sustainable Development: towards better practice' (1998). This guide aims to help planners and others how they can incorporate sustainable development principles into plans. This encourages a transition to sustainability, yet also could lead to better preparedness for climate change. Hence this is an example of unplanned adaptation.

The rest of the cross-sectoral examples are of planned adaptation. For example, Yorkshire Forward (the Regional Development Agency for the Yorkshire and Humber area) Climate Adaptation Toolkit (2004) which aims to help businesses identify potential impacts of climate change and look to how they can adapt over the next few years. The National Assembly for Wales and Devon County Council provide further good examples. See Boxes 3.5 and 3.6.

Box 3.5 The National Assembly for Wales – an example of planned adaptation in practice

The National Assembly for Wales has produced guidelines in a report entitled 'Community Leadership and Climate Change Guidance for Chief Executives of Welsh Local Authorities' (2002). These guidelines are intended to help local authority Chief Executives to lead response to the challenge of climate change. Adaptation is clearly mentioned in the foreword by Sir Harry Jones, leader of the Welsh Local Government Association, and Sue Essex, Minister for the Environment.

Box 3.6 Devon County Council – an example of planned adaptation in practice

Devon County Council declared its commitment to address the challenges of climate change at a local level by signing the Nottingham Declaration on Climate Change in July 2004. In doing so the Council agreed to prepare a plan with local communities to address the causes and effects of climate change and to identify ways in which we can adapt. Devon County Council has subsequently prepared a County Climate Change Strategy which is currently undergoing consultation (finishing at the end of May, 2005). It is a plan to address the causes and effects of climate change and to identify ways in which we can adapt. Climate change impact assessment is involved in the strategy as a way of reducing vulnerability - part of adapting to climate change. It also emphasises how to communicate about climate change, and addresses mitigation measures.

Drivers of adaptations

The main drivers behind many of the adaptations found are climate change, extreme weather events, flooding or other weather-related impacts. That is not to say that climate change or weather changes are the only drivers of adaptation, clearly, economic development, financial security, and environmental concerns are also important in leading groups and individuals to find out about climate change or to implement changes, see Box 3.7. For example, biodiversity and conservation issues are specific drivers for climate change adaptations by the Environment Agency, i.e. conservation measures are used in some way to deliver adaptation.

Box 3.7 Drivers of adaptation in the Environment Agency

- Ministerial and official statements on climate change
- Uncertainty about the priorities to be afforded to climate change
- The impacts of climate change on biodiversity and conservation
- Sustainable development
- Local impacts of climate change and impacts on future lifestyles
- Climate change perceived to be already occurring and threatening
- Need to prepare for future climate change impacts

Bristol City Council has a variety of initiatives related to climate change adaptation and note that these initiatives are driven by a recognition that climate change is happening and impacting on the City, and therefore, there is a need to respond to the impacts. On a larger national policy scale, the former DETR (2000) were driven to commission a report (ERM, 2000) entitled, 'Potential UK adaptation strategies for climate change'. This study was driven by a need for policy makers to understand the nature and scale of climate change risks, and where active steps would need to be taken to adapt.

3.2 Water

This section addresses adaptation in the water sector. The water sector comprises two parts: water supply and demand (primarily dealing with private and public water companies); and inland and coastal flood management in the UK. We turn first to review adaptations occurring in the water supply sector.

3.2.1 Water supply¹⁰

Introduction

The inventory shows that both public institutions and private organisations are taking climate change seriously, but efforts to respond are still at an early stage, hence there are many more examples of private and public sector groups building adaptive capacity, than implementing adaptation actions. Some implementation is occurring in the private sector, with *ad hoc* examples of large and small firms adapting. The legislative framework appears to be in place for firms to adapt, which will largely depend on financial and risk perceptions of climate impacts. Public sector institutions at different scales appear concerned with water conservation and supply and are aware of the increasing number of links being made between water supply and climate change.

In the public sector, the majority of outputs are in the form of building adaptive capacity through funding and supporting research, information dissemination, establishment of networks and partnerships and so on. In England and Wales, where water supply is provided by the private sector firms will have to take the operational lead on responding to climate change, following guidance and advice from economic and environmental regulators. In Scotland and Northern Ireland, where water supply is still provided by the public sector, government will have to take a policy and operational lead. Finally, legislation, such as the Water Act 2003 and the EU Water Directive at the national and international scale are important drivers of adaptation in the water sector in the UK.

¹⁰ For more information on the history of the water supply sector in the UK, see Annex 1.

Institutional range of adaptation

In the water supply inventory we have found approximately 60 examples of adaptation. These include adaptations across all sectors, including public, private and other. The majority of examples are within the public sector, particularly concerning government Ministries and Departments, and government agencies. There are also some examples of adaptations in government funded research institutes, devolved administrations, and local authorities. There are a number of examples in the private sector, most of which are private water companies. Other examples relate to voluntary, community and NGO adaptations, and associations and networks. In this part of the inventory there are no examples of individual level adaptation (see Box 3.8 for examples).

Box 3.8 Examples of institutions adapting in the water supply sector

Public

- Government Ministries and Departments, e.g., EU Water Framework Directive, Defra, House of Commons Environment Committee;
- Government agencies, e.g., The OfWat, Drinking Water Inspectorate, Environment Agency;
- Government funded research institutions / programmes, e.g., UKWIR, Tyndall Centre;
- Devolved Administrations, e.g., Scottish Executive, SEPA, Scottish Water Service Authorities, Aberdeen City Council;
- Regional Government Agency, e.g., East Midlands Regional Assembly
- Local authority, e.g. Hampshire County Council, London Borough of Newham;

Private

- Numerous water utilities, e.g. **Thames Water, Anglian Water, etc.**

Other

- Community, voluntary and NGO, e.g., Greenstreet
- Associations and networks, e.g., UKWIR, WaterUK, Thames Estuary Partnership, Southeast Climate Change Partnership.

Adaptation outputs

There is a good variety of outputs being generated from the adaptation work occurring in these examples. These include directives, reports, programmes, consultation documents, reviews, strategies, standards and guidelines, awards, forums, guidelines, partnerships, management plans, research, planning policy, schemes, investment and promotion, information provision, changing practices, and advice.

Classification of adaptation: Implementing adaptation actions and building adaptive capacity

The literature on adaptation in the water sector indicates that few companies have yet begun to implement adaptation actions despite actively seeking ways forward and having built adaptive capacity. The inventory illustrates fewer examples of implementing adaptation than building adaptive capacity. There are 10 examples of implementing adaptation actions in the inventory versus 50 examples of building adaptive capacity.

The examples of implementing adaptation are mainly occurring in the private sector and in government agencies, such as the Environment Agency. Some water firms are taking a lead in implementing adaptation actions, such as Portsmouth Water, Yorkshire Water, United Utilities, South East Waters, Severn Trent Water, Thames Water, and Gusto Homes.

An example of implementing adaptation in the water supply sector can be seen in Gusto Homes, a small, privately owned house-building company in Newark, Nottinghamshire (see Box 3.9 for further information). This example illustrates that implementing adaptation actions are occurring in small firms driven by committed individuals, which have implemented ideas introducing new systems / technology for rain water harvesting. The idea has now been transferred to other development companies who also want to adopt this type of technology.

Box 3.9 Example of implementing adaptation in the private sector

For its Millennium Green project near Newark in Nottinghamshire, 24 homes and the company's own office were fitted with 'Freerain', an advanced rainwater harvesting system developed by Gusto. Two of the houses were fitted additionally with equipment providing monitoring data direct to Severn Trent Water. The aims of the project were twofold: firstly, for the developers themselves to learn about the efficacy of such systems and to develop their understanding of them; and secondly, to raise awareness of the technologies through practical demonstration and dissemination. The rainwater system uses underground storage tanks big enough to provide non-potable water to the home for 18 days. If the supply of rainwater becomes low, the tank is automatically topped up by mains supply. Homeowners are able to observe whether their tank is being supplied through the mains by a light in the control box. The harvested water is used in the homes for toilet flushing, washing machines and for gardening purposes. The use of rainwater in washing machines has the added advantage of reducing the amount of detergent required as it is softer than mains water.

As a result of the success of the Millennium Green project, the company has been increasingly asked to provide complete rainwater harvesting systems to other development companies and has experienced a rapid increase in demand over the last 6 months. Gusto has also been instrumental in the recent establishment of a new trade body, the Association of Rainwater Recycling Companies, to encourage high standards in the design and provision of such systems.

Water service companies such as Yorkshire Water, Severn Trent Water and Thames Water are also implementing adaptation actions in various ways (see Box 3.10 for further information).

These companies are implementing adaptation actions by investing financial resources into infrastructure improvements (such as sewage services). These investments are driven not simply by climate-related events, but more generally by UK and EU legislative requirements.

Box 3.10 Example of numerous ways of implementing adaptation by Thames

Water

Thames Water unveiled in January 2005 that it would invest £3.1 billion record programme of investment to improve water and sewerage services over the next five years. Thames Water plans building a £700m reservoir in Oxfordshire and a £100m desalination plant at Beckton, East London (The Guardian, Monday October 27, 2003 www.guardian.co.uk accessed 14/3/05).

A planning application for the construction of the mainland UK's first desalination plant, is pending that would treat salty water from the tidal Thames in Newham, for public supply.

The company's 2002 annual report indicates that the company has also increased investment in various sewage treatments after receiving fine of £5000 for discharge of untreated sewage sludge from East Calder sewage treatment works, after heavy periods of rainfall. Thames Water investment in leakage control was hampered in 2001 by unusual UK climatic conditions, which caused the soil to swell and shrink excessively, resulting in an abnormally high rates of bursts. Since then, they are undertaking validation exercises to assess the cost and benefits of increasing their rate of water mains renewal.

Thames water is also involved in promoting water efficiency in the domestic household giving out free 'hippobags' to save on water flushing (see www.thames-water.com/waterwise).

Severn Trent is another excellent example of implementing adaptation actions. It is part of Severn Trent Plc, an international utility services and environmental solutions company. Severn Trent Water is the world's fourth largest privately-owned water company - serving over 8 million customers across the heart of the UK, stretching from the Bristol Channel to the Humber, and from mid-Wales to the East Midlands (see Box 3.11).

Box 3.11 Implementing adaptation actions in the West Midlands

Severn Trent Water is placing a great deal of importance on research into climate change and its' potential impact upon the communities it serves, the environment and our business. Its managing director, Brian Duckworth, has described the challenge presented by the impacts of climate change as, 'the number one environmental problem for us all'. Severn Trent Water is taking this threat seriously and has joined forces with the Midlands Environmental Business Club (MEBC) to begin to identify potential impacts on the West Midlands. This study was run under the guidance of the United Kingdom Climate Impacts Program (UKCIP). In response to water conservation it has set up a Water Efficiency Strategy. Its Water Efficiency report (2002) specifically mentions climate change.

Severn Trent is saving water supplies for example, through a £10 million investment programme, so that River Trent water can be used to support supplies for up to 3 million customers in the East Midlands. All the water they take from rivers and boreholes is controlled by licences from the Environment Agency. They have reached their lowest ever levels of leakage, using an extensive reduction programme, e.g., invested heavily in replacing old pipes, over 700 km of them in 1998/9; repaired over 2,000 mains a month since 1995; has its own Leak Detectives and faster response times have helped; and repaired over 1,000 customers' private supply pipes free each month. It also maintains over 1200 km of footpaths and Rights of Way, and claims to have planted well over a million trees since 989. Severn Trent Water Ltd's business plan includes submissions to deal with historical and new flooding events but has yet to be agreed. New sewers are not designed to a standard with an allowance for climate change.

This investment in implementing actions is a function of the high level of awareness of climate change in the water supply industry, and potentially high susceptibility. This could have been driven by government policy which while promoting adaptation is encouraging building adaptive capacity rather than implementing actions. By way of illustration, the fourth periodic review of OfWat (2005-2010) explicitly requires water supply companies to consider climate change in their projections of future requirements. In practice, no water supply company plans involve specific 'concrete' adaptations to climate change, although some included more detailed investigations into specific projects in anticipation of specific actions in the next investment review in 2009 (Arnell and Delaney, 2005). In developing assessment procedures and incorporating them into the investment review the regulators have already forced companies to consider the potential impacts of climate change in a consistent and rigorous manner, yet they have not forced them to act.

Building adaptive capacity in the water sector is largely, but not exclusively, taking place in the public sector. Both Defra and the Environment Agency, for example, identify climate change as one of the major drivers behind strategic visions for future water policy, and through these strategic visions raise awareness of climate change in the

water industry. At a more operational level, the water industry funds research into specific climate change issues, such as the development of methods to apply scenarios in water planning at the resource zone scale.

Legislation is also building adaptive capacity in England and Wales with the introduction of two new pieces of legislation: the Water Act 2003 and EU Water Framework Directive. The Water Act 2003 requests that all new licences will have time-limits, to increase flexibility in catchment management and allow people to adapt to changes in the environment and climate (Environment Agency, 2004). Until now water catchment management plans in the UK have not taken into account climate change. They implicitly include planned development over 5 years which is driven by the Water Framework Directive (rules stipulate 5-6 years).

Characteristics of adaptation

The majority of adaptations are organisational-related, followed by policy and behavioural-related. Out 60 examples of adaptation 12 are policy related adaptations and are all in the public sector. There are 31 organisational related adaptations, spanning all types of institutions. There are five examples of behavioural adaptations and ten examples of adaptations that are considered to demonstrate both organisational and behavioural characteristics. Policy-related adaptations include the EU Water Framework Directive, Defra reports, programmes and consultations, reviews by OfWat, standards by the Drinking Water Inspectorate, and the Environment Agencies Water Framework Directive Programme. An example of organisational-related adaptations would be the Scottish Minister's Guidance on sustainable development adopted by Scottish Water in 2003. Scottish Water has pledged to support sustainable development targets with an action plan in its 'Sustainability Report' for 2002 / 2003, a one off report on the objectives of Scottish Water (Scottish Water Sustainability Report (2002/2003)). An example of behavioural related adaptation is Southwest Water's engagement in a mobile 'Waterwise' road show to encourage customers to save water. This is not only to protect the environment, but also to help avoid the need to build new reservoirs.

Scale of adaptation

At the administrative or management scale there is one important example of building adaptive capacity at the European scale, which is the EU Water Framework Directive (EU, 2000). This is a major European civil-society led legislation that aims to resolve European Water Policy problems. The Directive harmonises existing EU legislation on water management and provides for the first time a coherent framework for EU water policy. The Directive's provisions do not relate simply to standards of water protection but also to organisational and procedural aspects of water management and formalise the concept of integrated river basin management. The Directive has great potential for improving water resource management, such as integrated catchment solutions which should help to address some of the more complex and difficult issues facing water resource management. It could, for example, help to introduce changes in land use that improve water quality and the management of flood risk and drought (www.europa.eu).

There are approximately 24 examples of adaptation at the national scale, 9 from the Devolved Administrations, 5 regional, and 14 local. Local examples of adaptation include in particular local public authorities and local water utility companies in the private sector. For example, a local authority that is particularly active is the London Borough of Newham which supported the Thames Water's proposal to build a desalination plant in East London to ensure future provision of water to the capital, however this initiative was vetoed by the Mayor of London on the grounds that it would consume too much energy (this is also potentially an example of maladaptation).

Regional examples of adaptation include efforts by regional water companies, such as Anglian Water and Severn Trent Water. Also the East Midlands Regional Assembly, which has produced a water resources strategy for the East Midlands that shows that demand management and flexibility in the face of uncertainty will be required (an example of building adaptive capacity at the organisational scale).

At the devolved scale there are various examples, such as the Scottish Executive strategies for adaptation in the Scottish water sector laid out in the report 'Potential Adaptation Strategies for Climate Change in Scotland' (Kerr et al, 2001).

At the National scale Defra, government agencies, and research related institutions such as the Environment Agency, UKWIR, and the Tyndall centre have produced reports and are carrying out research on water and climate change, (for example Arnell (2004) see inventory for further examples).

There are examples occurring at a range of geographical locations ranging from 9 examples at the UK level, 20 in England and Wales, 7 Scotland and the rest in, for example, East Midlands, London, Mid-Glamorgan, Durham, Aberdeen, Kent, Cumbria, Dorset, Yorkshire, Portsmouth, and so on (see inventory).

Purposefulness of adaptation

Because the public institutions such as Defra, OfWat and the Environment Agency explicitly require water supply companies to consider climate change in their projections of future requirements, most adaptations are planned. However, there are 20 examples of unplanned adaptation mostly in the private sector. These include, for example Portsmouth Water, which states that it has a duty to promote the efficient use of water supplies but does not make any reference to climate change. In the public sector an example of unplanned adaptation is the Drinking Water Inspectorate Standards and enforcement of water quality in companies (but this builds adaptive capacity). Examples of planned adaptation are particularly prevalent among the examples associated with government agencies, e.g. the Environment Agency, government funded research institutions, and devolved administrations, and other examples (e.g. associations and networks). For example, the Southeast Climate Change Partnership promotes awareness of the challenges of climate change adaptation and will work with partners to develop common approaches to incorporate climate change into spatial planning for water resources issues.

Drivers of adaptation

The inventory illustrates that actions undertaken at the company level are also not always a direct response to climate change and are often a result of other drivers. These actions, such as, promoting water efficiency among customers, could be considered an example of building adaptive capacity. In some cases climate change, directly or indirectly, has a role in driving forward adaptation. In particular the literature in this sector cites stress on water resources, dry weather, extreme weather events, and sea level rise as drivers. Regulations and standards such as ISO9001 and corporate social responsibility (especially in the private sector) and environmental best practice are also significant drivers. Others are listed in Box 3.12.

Risk management principles are also important drivers of adaptation in the water sector. For example, although water utilities in England and Wales are abiding by 'new' environmental standards approved by the Environment Agency¹¹, companies' adaptation strategy has been to wait for more information, in the form of the next periodic review process before making any further decisions on adaptation. These decisions are based on risk management principles, with the financial implications of climate uncertainties playing a significant role (Arnell and Delaney, 2005).

¹¹ In their current environmental improvement programme, water companies will spend £5.3 billion on nearly 7,000 projects to improve rivers and coastal waters in England and Wales. This will also protect over 100 important wildlife sites. This investment programme is known as the National Environment Programme (NEP) and covers the five years from April 2000 to March 2005. It is part of the water companies' third Asset Management Plan (AMP3) since privatisation and has been agreed by Government after discussions with the Environment Agency, water companies and Ofwat. (<http://www.environment-agency.gov.uk>. Accessed 27.04.05)

Box 3.12 Drivers of adaptation in the Water supply sector

- EU Water Directive;
- Regulations such as OfWat, Standards ISO 9001;
- Sustainable development policies;
- Population pressures and increasing demands for water abstraction;
- Government interests;
- Champions;
- consultations
- Sectoral competition;
- Biodiversity Action Plans and conservation;
- Water pollution from agriculture;
- Water shortages;
- River flows,
- Climate change
- Regulatory drivers

3.2.2 Flood management¹²

Introduction

Institutions adapting to climate change in the flood management sector span public, private and other kinds of institution. The majority are in the public sector, including in the Devolved administrations. There are many different kinds of adaptation outputs listed as examples in this sector, ranging from planning policy guidance to flood risk maps and local activities. Adaptation is occurring both in terms of the implementation of adaptation actions and the building of adaptive capacity across types of institution but there are many more examples of the latter. We found many different types of adaptation (policy, organisational, behavioural), although policy adaptations are only occurring in the public sector. Adaptations are occurring at a range of geographic locations, however, most of these are observable at the national scale and in the devolved administrations (particularly in the public sector). Other sectors including voluntary, community and NGO-type institutions demonstrate more evidence of local scale adaptations. Most of the examples of adaptation in this sector are planned, i.e. deliberately initiated in response to the need to adapt to the impacts of climate change. However, it is clear that there are many drivers of adaptation in the inland and coastal

¹² For more information on the recent history of coastal and inland flooding in the UK, see Annex 2.

flooding management sector, aside from climate change (though this is clearly one). We now turn to address the inventory data on this sector in more detail.

Institutional range of adaptation

There are 50 examples of adaptation in this inventory across public, private and other organisations. The majority of examples are in the public sector, particularly concerning the devolved administrations, government agencies and local authorities. Examples are also apparent within government Ministries and Departments and government funded research institutes and programmes (see Box 3.13).

Box 3.13 Examples of adaptations by flood-related institutions

Public

- Government Ministries and Departments, e.g., ODPM, Defra,
- Government agencies, e.g., Office of Science and Technology (OST), Environment Agency;
- Government funded research institutes / programmes, e.g. The UK Foresight Programme
- Devolved Administrations, e.g., Scottish Executive, Scottish Natural Heritage, SEPA, the Welsh Assembly;
- Regional Government Agency, e.g., East Midlands Regional Assembly and Yorkshire Forward;
- Local authority, e.g. Kent, Surrey, and Shropshire County Councils, North Cornwall District; Norfolk Broads Authority

Private

- Private sector: Severn Trent, Norwich Union;

Other

- Community, voluntary and NGO, e.g., National Trust, Cumbria Community Foundation, WWF, Scottish Flood Appraisal Groups
- Associations and networks, e.g., Thames Gateway London Partnership, Association of British Insurers, Construction Industry Research and Information Association.

There are a number of adaptations in government, scientific, regional and local planning bodies as well as agencies, NGOs and private individuals addressing the impacts of sea level rise on coastal defence and the issue of increased precipitation in flooding zones, in particular when conservation or livelihoods are at risk. These bodies include Defra (2004b) Making Space for Water: Developing a New Government Strategy for Flood and Coastal Erosion and Risk Management in England. This strategy originally published in 1993 was reviewed in light of drivers for change, including the latest predictions on climate change. The paper outlines ideas for dealing with all types of flooding and states that government funding of the England Wales Flood Defence

Programme is set to rise between 2005 and 2008. In the Devolved Administration the Scottish Executive has a National Flooding Framework since 2003 (Scottish Executive Environment Group, 2004) (see Box 3.14 for further details).

Box 3.14 Scottish Executive National Flooding Framework 2003

Action points include: improve awareness of the risks of flooding through the provision of better flood risk information and additional flood warning systems; publish revised national planning policy intended to strengthen the ability of planning authorities to prevent unsuitable further development where there is significant flood risk; spend £40 million over the next three years to reduce flood risk for 1850 properties; seek to reduce the risk of sewer flooding by continuing to encourage the use of sustainable urban drainage systems (SuDS); Work with Scottish Water to ensure that such systems are properly maintained; manage flood risk better by improving national guidance and administrative procedures for promoting new flood alleviation schemes; ensure joint working between local authorities, SEPA and Scottish Water to improve flood risk management and will establish a national technical advisory group; and to ensure better support to those affected by flooding. As part of this framework the Executive has continued to increase resources to support local authorities' investment in flood defences — to £89m in total for 2005-2008. Funding was provided to extend the Floodline68 flood warning telephone and Internet service to cover Scotland. For more details see: (<http://www.scotland.gov.uk/about/ERADEN/ACEU-AQT/00016919/strategies.aspx> (Accessed 8 April, 2005))

The Scottish Executive Central Research Unit published in 2002 a review of flooding risk in Scotland entitled 'Climate Change: Flooding Occurrences Review' (Entec *et al*, 2002), which highlighted the importance of land use planning in adaptation policies, specifically in adapting to the increased risk of flooding because of climate change. It seems that an awareness of the importance of planning as an adaptation tool has been recognised in Scotland. This does not seem to have been recognised to the same extent in England or Wales (Cichton, 2004).

Adaptation outputs

There are different types of outputs, such as planning policy guidance, reports, strategies, flood risk maps, flood defences, plans and schemes, education, programmes, policy and legislation, investment, national frameworks, task groups, local activities and local action plans, partnerships, scoping studies. For example, production of flood risk maps by the Environment Agency and Norwich Union. Local actions include the activities by 21 flood appraisal groups across Scotland. Most Scottish Authorities, including those with a potentially serious flood hazard have also set up Flood Liaison and Advice Groups, to concur with the recommendations of the relevant planning

guidelines (SPP7) and these now cover over 90% of the population (Crichton, 2004). The Association of British Insurers has also produced guidance both to policy makers and chief executives (2004a), and to parliament (2004b) on climate change and the insurance sector.

Classification of adaptation: Implementing adaptation actions and building adaptive capacity

There are more examples of building adaptive capacity in this sector than of implementing adaptation actions, with 11 examples of implementing adaptation, one that is both implementing adaptation and building adaptive capacity and 38 examples of building adaptive capacity. Implementing adaptation actions include for example, the Environment Agency's efforts to build further flood defences in Carlisle and Lower Eden (on the River Eden) (Environment Agency, www.environment-agency.gov.uk/regions/northwest) (for more detail see Box 3.15). The Environment Agency is also implementing adaptation in working with Defra, local authorities and Severn Trent to reduce flood risk along the length of the River Severn. This includes looking at the causes of flooding, performance of existing flood defences and viability of flood management options.

Box 3.15 Building flood defences in Carlisle and Lower Eden

Following the flooding in January 2005, a proposal for £35 million GBP was put forward by the Environment Agency to be invested in flood defence in this area. The following proposals are under review:

Do nothing - do not undertake any maintenance or improvement of existing structures; use flood warning systems and contingency planning to reduce the risk of damage to people and property;
Hold the line, ie, use the existing line of defences at the present location and level;
Improve the line, ie, raise the height of existing defences at the present location;
Retreat the line, ie re-align the defences away from the river;
Increase storage, ie that areas of land will be used as flood plain storage to reduce water levels.

These options have been assessed in terms of technical sustainability, environmental impacts and economic viability. The Agency is working with a number of statutory and non-statutory agencies, including English Nature and Defra to ensure that all options are fully considered and assessed. As yet no decision has been made. EA will publish their recommendations in spring 2005. Work on the scheme will start in 2006, finishing in 2010. Source: http://www.environment-agency.gov.uk/regions/northwest/850243/870762/871001/?version=1&lang=_e&lang=_e&textonly=on&format=# (last accessed 14/3/05)

The Environment Agency is also involved in the maintenance and operation of the Thames Barrier in London. The Thames barrier, which addresses flooding linked to the impacts of climate change in an urban area is the best example of adaptation in practice found so far. This example illustrates that decisions taken at one point in time coincidentally also have adaptation benefits (for more information see Box 3.16).

Box 3.16 The Environment Agency and the Thames Estuary 2100 (TE2100)

Following the 1953 floods the Thames Barrier and associated defence improvements were planned and built over a 30 year period to protect London to a high standard from tidal flooding. Given the challenge of climate change and the long timescales required to plan for any changes, the Environment Agency has set up the Thames Estuary 2100 (TE2100) project. This project will develop a Flood Risk Management Plan for London and the Thames Estuary for the next 100 years.

The design of the Thames Barrier allowed for sea level rise but did not make any specific allowance for changes due to climate change in fluvial flows coming down the Thames or the size of storm surges arising in the North Sea. Rising sea level and rapidly increasing development within the tidal flood plain mean that flood risk is increasing and by the year 2030, improved arrangements will be required if flood protection standards are to be maintained at present levels.

TE2100 has to devise a strategy that will cope with the uncertainties that climate change and differing socio economic futures present. The project looks to manage flood risk by a balance of relevant measures such as the timing and design of future flood defences, resilience of new and existing development and flood warning systems and emergency responses.

Source: Tim Reeder Project Scientist the Environment Agency

Another example of implementing adaptation is in Essex Wildlife Trust which has won an award for the largest coastal realignment project ever undertaken in Europe, which will convert over 84 hectares of arable farmland into salt marsh and grassland. The farm that owns the land also aims to show how the re-creation of salt marsh can act as a sustainable sea defence (Trust News, 2005).

Examples of building adaptive capacity include the National Assembly for Wales, which produced a Welsh Climate Change Programme in 2001, called 'Climate Change Wales: Learning to live differently' which includes consideration of the impacts of climate change on Wales and what it can do to adapt, highlighting projects such as the land slipping research project in the Rhondda Valley in South Wales (National Assembly for Wales, 2001). The Scottish Planning Policy 7 is also an example of building adaptive capacity to address the likelihood of overtopping or failure of dams and embankments in the event of climate change. This policy now entitles local authorities to enforce the

Reservoirs Act of 1975 and have the power to require reservoir owners to commission additional risk assessment (Scottish Executive, 2004a). This particular policy helps to build local authority capacity to respond to climate change impacts on infrastructure. The Regional Climate Impacts Scoping Studies, e.g. Yorkshire Forward (2002) are good examples of regional efforts to build adaptive capacity in the water sector as well as other sectors (these studies were all conducted in association with UKCIP and are listed in the non-sector specific inventory).

Characteristics of adaptation

Ten policy-related adaptations, nineteen organisational, two behavioural and eight mixed organisational and behavioural adaptations were found.

Policy related adaptations include outputs from Government Ministries and Departments and the Devolved Administrations, such as the ODPM's PPG 25: Development and Flood Risk (Defra, 2004a). The planning policy guidance explains how flood risk should be considered at all stages of the planning and development process in order to reduce future damage to property and loss of life. It highlights the importance that government attaches to the management and reduction of flood risk in the land-use planning process, to acting on a precautionary basis and to taking account of climate change and aims to reduce vulnerability to the dangers and damages caused by unmanaged floods (specifically regarding location of developments and drainage systems). The Scottish Planning Policy Guideline (SPP7) replaced sets out Scottish Executive's planning policy on new development and flooding (Scottish Executive, 2004a). The SPP has an important role to play in the national framework flooding avoidance and alleviation. It complements the requirement to promote sustainable flood management as included in the Water Environment and Water Services (Scotland) Act 2003 (*ibid*).

An example of organisational related adaptation is given by the Scottish Executive which has increased resources available to local authorities and flood prevention schemes to £89 million GBP over the next 3 years (Cook, 2005).

An example of behavioural- related change is illustrated in the Environment Agency's report in 2001 entitled 'Lessons Learned from the Autumn Floods 2000' which brings to the fore the importance of social memory in adapting to climate related events. This is intended to help people to adapt to the impacts of climate change by developing an understanding of peoples perceptions of climate change and how they should react and adapt (Environment Agency, 2001).

Scale of adaptation

At the administrative and management scale most of the examples are occurring at the National scale (19 examples), Devolved Administrations (15 examples) (some of which could be considered local), regional (5 examples), and local (10 examples). At the local scale of administration they include both implementing adaptation and building adaptive capacity. Many National, devolved and regional scale examples have already been given so far in this section. At the local scale examples include the Cumbria Community Foundation in Cumbria, England, which set up the Cumbria Flood Recovery Fund (see Box 3.17 for further information).

Box 3.17 Cumbria Flood Recovery Fund

Carlisle City Council pledged £50,000 of funds to the recently established Cumbria Community Foundation Fund set up to support individuals and communities affected by the floods. The charity gives grants to voluntary and community groups throughout the county. The Flood Recovery Fund is for charitable purposes in connection with the relief of hardship within the county caused directly or indirectly by storm damage and flooding.

Source: <http://www.carlisle.gov.uk/carlislecc/main.asp?page=817> (last accessed 250505)

Kent County Council provides another example of local adaptation to climate change (building adaptive capacity) in the form of its Environment Strategy (Kent Environment Strategy, 2005) which lays out climate change as a key environmental challenge. It mainstreams climate change into all sectors and the Council has also drawn up a planning agenda to deal with climate change risks such as flooding and storm damage. At the local scale in the Devolved Administrations Aberdeen City Council is taking a lead in Scotland by developing its own Climate Change Action Plan and in England Surry County Council, which builds adaptive capacity through being part of the South

East of England Climate Change Partnership (for further information see <http://www.surreycc.gov.uk>).

There are examples occurring at a range of geographical locations ranging from 12 examples in the UK, 6 examples of England and Wales, 2 examples from Wales, 14 examples from Scotland, and others more specific, e.g. East Midlands, Aberdeen, North Cornwall, Surrey, Shropshire, Essex, and Cumbria.

Purposefulness of adaptation

There are nine examples of unplanned adaptation and 37 planned. Unplanned adaptation at the national scale include for example, the Scottish Executive's Flood Prevention and Drainage Act (Scottish Executive, 1997), requiring local authorities to prepare reports specifying measures they should take to prevent flooding of their land. At the local level an example of unplanned adaptation in the private sector is the Severn Trent Water Flood Relief Plans unveiled in Shropshire. While a planned adaptation in the private sector is Norwich Unions Flood Maps (see Box 3.18).

Box 3.18 Example of Planned adaptation to climate change: Norwich Union Flood Maps

More than 600,000 properties in flood risk areas could now qualify for insurance thanks to the launch of a revolutionary flood map of the UK. The new digital map, developed by Norwich Union, is the largest and most accurate ever undertaken in Britain and is being used to pinpoint the risk of river flooding to individual properties. And for the five million people living or working in flood risk areas across the UK, this means more accurate premiums and a better understanding of the risk to their property. Norwich Union is one of the first insurers to set premiums based on a particular address rather than just a postcode band, for both residential and commercial properties. As well as showing whether a property is at risk, the map shows how often a flood is likely to occur and to what depth. The multi-million pound project is initially launching in parts of Shropshire and Norfolk and will be rolled out across the UK, starting with high-risk flood areas. It is anticipated that the project will be completed by the end of 2004. Shropshire has been selected as a key launch area following the devastating floods of October 2000 and ongoing flood risk. Norfolk was chosen because of the continued risk to properties on low-lying land. Source: Norwich Union, 2005.

Drivers of adaptation

The main driver of these adaptation examples appears to be climate related impacts, such flooding and associated risks, coastal erosion, storm damage and anticipated sea

level rise and increased temperatures. Deaths following floods have also lead to increased resources for flood prevention schemes in Scotland provided by the Scottish Executive in 2005. Government priority is an important driver, along with national and international regulation, and financial costs of flooding, see Box 3.19.

Box 3.19 Drivers of adaptation in the coastal and inland flooding sector

Some further explanations of the drivers given in the literature include:

- Coastal defence
- Coastal inundation
- Land slides
- Biodiversity loss
- Sustainable drainage systems
- Climate change
- Financial management
- Regulations

3.3 Construction¹³

Introduction

The inventory demonstrates that there are a range of institutions demonstrating some degree of adaptation to climate change. These are occurring in both public and private institutions as well as a range of other kinds of institution. Collectively, they are producing a wide variety of outputs ranging from planning policy at national levels to corporate social responsibility reports and lobbying. By far the majority of the examples of adaptation that we collected are of building adaptive capacity rather than actual implementation of adaptation actions in this sector. There is much awareness of climate change adaptation issues in the public sector; planned examples of climate change are predominant and mainly concern planning. There is also a lot of awareness in other types of institution (particularly associations and networks) but not in the private sector which is building adaptive capacity predominantly in an unplanned context. Examples mainly concern climate change mitigation and drive for sustainable construction. More than half of the examples in the transport sector as a whole are however, examples of planned adaptation. This suggests that the sector overall is taking the risk of future climate change on board and is beginning to prepare. Most of the examples relate to organisational level adaptation. Some of them are policy-related, principally concerning development planning. Most adaptations are occurring at the National scale and in the Devolved administrations, suggesting that little is being done on more local scales to either build adaptive capacity or implement adaptation actions. The drivers of adaptation in the construction sector are varied and many, including aspects of climate change itself. However it is clear that climate change is only one of lots of pressures on the industry which lead to both adaptation initiatives and barriers to these.

Institutional range of adaptations

The construction inventory comprises 64 examples of adaptation in the construction and planning sector in the UK. These examples represent adaptations occurring in all types of institutions; public, private and other. These are fairly evenly spread across the three

¹³ See annex 3 for a summary of the academic literature on adaptation in the planning and construction sectors.

types of institution. Some of the institutions adapting in this sector are presented in Box 3.20.

Box 3.20 Examples of institutions demonstrating examples of adaptation in the Planning and Construction sector

Public

- Government Ministries and Departments, e.g., EU, ODPM
- Government Agencies, e.g., Energy Saving Trust
- Government programmes, e.g., Sustainable Buildings Task Group, Sustainable Construction Task Group, CABE
- Government Funded Research Institutes / Programmes, e.g., Tyndall Centre for Climate Change Research; AUDACIOUS, Oxford Brooks University School of Architecture, Centre for Urban and Regional Ecology
- Devolved Administrations, e.g., Scottish Executive, Welsh Assembly Government, Departments for Regional Development and the Environment Northern Ireland, SNIFFER
- Regional Government Agency, e.g., Southwest Regional Assembly, Sustainable Development Round Table for the East of England;

Private

- Private sector, 15 house building and construction companies, e.g., Taylor Woodrow and Telford Homes plc. Also the Renewable Energy Systems Group, and ARUP (a consultancy).

Other

- Community, voluntary and NGO, e.g., Care and Repair Cymru, Lockton Village (youth hostel);
- Associations and networks, there are numerous examples of these, e.g., Association of British Insurers, Sponge, Building Research Establishment, and the New Construction and Research Innovation Panel.
- Individual, e.g., local scale architect.

There are many examples of adaptation to climate change in the private sector (largely unplanned and building adaptive capacity). For example, Barratt Developments who have a number of environmental and sustainability policies, plans and awards. An example of a 'voluntary, community and NGO' adaptation is the Lockton Village youth hostel – a first for the UK. See Box 3.21.

Box 3.21 Lockton village youth hostel – an example of a 'Voluntary, community and NGO' adaptation to climate change.

Originally home to the village school, the old building has been insulated with sheep's wool. New features include showers heated by solar panels and a system that harvests rainwater to flush toilets. The new extension has a "living roof", the foliage of which provides a habitat for local wildlife as well as adding extra insulation. The £45,000 RES grant which Defra has contributed to this project has not only helped to create a beacon hostel which will showcase low-impact tourism; it will also start an education programme which show visitors how easy it is to become more sustainable at home. While many Defra grants are targeted at farmers and land managers, RES offers funds to support a wide range of projects from farm diversification through to community facilities and those which support rural tourism."

There are also lots of associations and networks which constitute examples of adaptation in practice in the construction sector. An example of planned adaptation (building adaptive capacity) is the Institution of Civil Engineers (ICE) which has links with the UK Climate Impacts Programme and other bodies. The ICE has held a number of events concerning the impacts of climate change on the built environment, has published some material (see inventory) and also works on sustainability issues.

In the public sector, there are lots of different kinds of institutions adapting to climate change as reflected in Box 3.20, for example, the Commission for Architecture and the Built Environment (CABE) funded by the Department for Culture, Media and Sport and the Office of the Deputy Prime Minister. One of CABE's objectives is to communicate clearly to the outside world, based on hard empirical evidence, the ways in which a better designed built environment can deliver greater long term value to society. CABE aims to help public bodies towards improved performance as a client, so that public buildings become beacons of design quality. CABE believes, as outlined in a report on environmental sustainability and the built environment), that: environmentally sustainable urban developments will be "designed for longevity, flexibility and adaptability with and understanding of the possible effects of climate change" (amongst other things); and that an environmentally sustainable building will be durable and able to adapt to future conditions and needs of users. A number of other examples will be given throughout this section of the report, and the reader can also refer directly to the inventory for more information.

Adaptation outputs

Outputs from this sector include directives, reports, planning policy guidance, and statements, consultation papers, guides, research projects, spatial strategies, planning frameworks, environmental and sustainability initiatives, corporate social responsibility reports, environmental design, collaboration with the UK Climate Impacts Programme, building, networks, lobbying, providing guidance, and education. In terms of planning frameworks, there are examples from the national to more local scales. At the regional

scale, is the OPDM Regional Planning Guidance 6 East Anglia (ODPM, 2004b), which notes the number of climate change impacts and necessary responses including that development proposals should be resisted on flood plains and that development plans should promote the use of sustainable urban drainage solutions.

Classification of adaptation: Implementing adaptation actions and building adaptive capacity

There are three examples of implementing adaptation actions in the private sector, associations and networks and individual. In the private sector Gusto Homes, a small privately owned housing company have fitted 24 homes in Nottinghamshire with an advanced rainwater harvesting system (see Box 3.9 for further information). The Association of British Insurers states that it is taking implementation actions in the UK, specifically laid out in its report entitled 'A changing climate for insurance' (2004). An architect in Norfolk has designed and built three eco-friendly houses that have incorporated design for adaptation, in addition to mitigation design (see inventory for weblink).

The rest of the examples are all concerned with building adaptive capacity. For example, ODPM produced a report in 2004 entitled 'The Planning Response to Climate Change: Advice on Better Practice' (ODPM, 2004c). It is intended to provide planning professionals with the state of knowledge on how they should respond to climate change. In the private sector Balfour Beatty is building adaptive capacity by employing various environmental initiatives which concern water efficiency amongst other sustainable development priorities.

The uncertainty involved in preparing for adaptations to climate change may be a reason why institutions, particularly in the private sector and operating at local scales, appear to be reluctant to engage in anticipatory action. These organisations also operate on relatively short-term time scales and are geared according to maximisation of profit with little interest in the longevity of the buildings they construct (e.g. Graves and Phillipson, 2000). Sorrell (2003) emphasises that issues of time, cost, and the structure of the industry lead to a lack of integration and difficulty in implementing energy efficiency considerations in building construction. It is, for example, considered to take longer and cost more money to design, assess and implement novel features (e.g. building according to 'green' designs) than to use tried and tested solutions. Sorrell also argues, that the lack of integration and fragmented nature of the industry also

means that learning and the development of integrated teams who may be able to deliver 'green' buildings is inhibited. The very nature and fragmentation / involvement of many actors in the construction industry may, therefore, account somewhat for little evidence of adaptation actions being implemented in the planning and construction sector (e.g. Hertin and Berkhout, 2003).

Characteristics of adaptation

There are 14 policy-related examples of adaptation to climate change, the majority being in the public sector. The inventory contains 46 organisational examples and two of behaviour related adaptation.

All the examples of policy are found in the government Ministries and Departments and the Devolved Administrations, and are occurring within the development planning system. For example, Planning Policy Guidance 25 (ODPM, 2004a), which guides against developing on land prone to flood under future climate change conditions. The Scottish Executive Planning Advice Note 69: Planning and Building Standards Advice on Flooding also sets out factors which contribute to flooding, noting that drainage assessments should take account of the expected impact of climate change. Planning legislations will serve increasingly as valuable adaptation tools as the Government plans for climate change (see, for example, Liso *et al.*, 2003). Examples of how adaptation considerations at the national planning policy scale feed downwards are presented in Box 3.23.

Box 3.23 Policy examples of adaptation occurring within the planning system

<u>Policy</u>	<u>Details</u>
PPG 25 Development and flood risk (Office of the Deputy Prime Minister, 2001 modified Sept, 2004)	Explains how flood risk should be considered at all stages of the planning and development process in order to reduce future damage to property and loss of life. It sets out the importance the government attaches to the management and reduction of flood risk in the land-use planning process, to acting on a precautionary basis and to taking account of climate change. Refers to reducing vulnerability to the dangers and damage caused by unmanaged floods (specifically location of developments and drainage systems).
PPS 11 Regional Spatial Strategies (replacing PPG 11)	The policies in this document need to be taken into account by regional planning bodies. It states that Regional Spatial Strategies need to consider long-term adaptation to climate change.
Regional Planning Guidance notes (e.g. RPG 6 East Anglia)	PPG 25 notes that RPG should identify, for example, areas where flooding issues are likely to be of regional significance and should set out regional policies to discourage inappropriate development in flood-risk areas. The Regional Planning Guidance Note for East Anglia (2001-2016) notes a number of climate change impacts and necessary responses.

While guidance is emerging to drive adaptation considerations in new development at a broad level, there is, as yet, no clear policy on issues relating to the maintenance of the existing built environment. This a major issue for old building stock (particularly social housing) which will be subject to the impacts of climate change over coming decades (see Hertin and Berkhout, 2003).

Organisational-related adaptations are occurring in the private sector, for example, environmental initiatives being carried out by Travis Perkins plc, Ogilvie Construction, and the Renewable Energy Systems Group, which is considering climate change that will influence the construction of planned wind farms, see Box 3.24.

Box 3.24 The Renewable Energy Systems Group – an organisational example of adaptation in the private sector

The Renewable Energy Systems Group (RES) is one of the largest and most successful wind energy companies in the world (more than 6000 MW of projects at various stages of development on four continents and have developed and built wind farms in the UK and abroad). Because a wind farm's life spans typically from around 20 to 25 years, many are in the planning stage and will not be built before say 2010. "We would like to adapt to climate change and to construct our wind farms with these changes in mind. However, the information from climate models seems to be such that wind speeds are either increasing in the future decades or decreasing in the future decades. Moreover, it is unclear how the probability of extreme weather events is going to change. Therefore, we have been unable to prepare for tackling the issue of climate change for our wind farm planning, construction and operation business." Therefore, the company is carrying out research into the impacts of climate change on the construction and planning of future wind farms. Climate change is likely to have impacts on the amount of energy produced by constructed and planned wind farms as well as on the occurrence of extreme wind speed events which have implications for wind farms.

The two examples of behavioural adaptation both concern architecture, one has already been referenced and the other concerns a research project at Oxford Brooks University, which recommends that climate change is considered when teaching students of building design. Behavioural change in this sector may become an important factor in driving adaptation in practice in the future, for example, leadership driving change in organisational culture (see, for example, Hertin and Berkhout, 2003). At present, much action on climate change adaptation (both planned and unplanned) concerns action by young property construction professionals, investor and media pressure, committed clients, etc., all of which are behavioural factors.

Scale of adaptation

At the administrative or management scale, most adaptations are occurring at the national scale and in the Devolved Administrations. There are some international, regional and local examples and some which span scales, for example, Carillion plc., a commercial building company which operates at national and regional scales. There is also an example of an individual adaptation which is that of the Norfolk architect noted above. At the local scale, there is only one example which is Telford Homes plc, which is a small company of 60 employees based in East London, the annual report states that it is committed to supporting the environment in its activities. The Devolved Administrations all have planning policies that take climate change into consideration.

The examples of adaptation to climate change in the construction sector are geographically located quite evenly across the UK.

Purposefulness of adaptation

In this inventory there are 37 examples of planned adaptation and 27 unplanned examples.

Unplanned examples of adaptation are mainly found in the private sector. Many of the private sector construction companies already referenced in this report (and see inventory) have numerous environmental and sustainability initiatives (building adaptive capacity, such as building water efficient systems) but do not address climate change adaptation. Despite UKCIP and government guidance, pressure from the insurance industry and action on sustainable development, awareness of climate change impacts and adaptation measures does not appear to be filtering down to institutions in the private sector; Hertin and Berkhout (2004) note that house-builders in the UK hold a view that there is a shortage of reliable and practical information about the impacts of information about the impacts of climate change and adaptation options for the sector. At the policy level, the Department of Trade and Industry provides a good example of unplanned adaptation in its report: 'Building a better quality of life - a strategy for more sustainable construction' (Department of Trade and Industry, 2000).

Other types of institutions demonstrate a mixture of purposefulness in their actions. An example of planned adaptation in public sector is the Sustainable Building Task Group, which produced a report in 2004 called 'Better Buildings - Better Lives' that was concerned with sustainable building and addresses pressures from climate change, e.g. periods of summer drought, and flooding, stating that the built environment must be constructed to withstand these conditions. See the New Construction Research and Innovation Strategy Panel as an example of planned adaptation to climate change (e.g. Lowe, 2001). See Box 3.25.

Box 3.25 The New Construction Research and Innovation Strategy Panel (nCRISP)

The mission of nCRISP is to 'prioritise and promote research and innovation that will sustain a first class construction industry and enhance the value of its contribution to the quality of the built environment and the wealth and well being of society'. nCRISP has links with government, industry and the research community, and considers the impact of climate change on the built environment and vice versa. The organisation has a Climate Change Task Group, formed to prioritise future research on the significance and effects of climate change on the built environment (various publications available). The remit of the task group is to focus on the impacts of climate change rather than mitigation measures: "Research is needed for the UK construction industry to plan for future construction and to provide solutions of adaptation to current infrastructure features amidst future climatic extremes." (Wilson and Burtwell, 2002:2) Reports produced advocate responsiveness and adaptation to climate change in the construction sector (in an 'effective and sustainable manner').

In Wales, an example of planned adaptation is the Welsh Assembly's report 'Changing Climate, Challenging Choices' (2000) which addresses the impacts of climate change on the built environment and planning issues for adaptation (as well as for other sectors). In Northern Ireland, the Rivers Agency and the Water Service are providing planned guidance on infrastructure design, which is cognisant of climate change. As an example of another type of institution, the Building Research Establishment, the UK's leading research expertise on building and construction, is an example of planned adaptation to climate change. It provides specific guidance on climate change adaptation in the built environment. The Association of British Insurers has taken climate change adaptation on board very seriously, by identifying the impacts and outlining practical options for adaptation within the construction industry (Association of British Insurers, 2003, 2004). This is perhaps one route via which adaptation considerations will filter down in the private sector institutions concerned with planning and construction.

Drivers of adaptation

There are a large number of drivers in this sector. Climate related drivers include climate change itself, and more specifically impacts such as extreme weather, heatwaves, flooding, wind and storm damage and subsidence. Regulations, policies and standards are powerful drivers, particularly the UK planning policy guidance and statements. Other policy-related drivers include national level Planning Policy Guidance, Planning and Compulsory Purchase Act 2004, the EU SEA Directive, ISO14001

standards, Climate change levy, and building regulations. A range of other types of drivers are also apparent in the inventory. These are listed in Box 3.26.

Box 3.26 Drivers of adaptation in the construction sector, (aside from climate change and policy related drivers)

- sustainable development / construction demands
- 'a need to create a common framework to promote energy performance in buildings'
- Climate change mitigation and energy efficiency
- Need for improved infrastructure, e.g., drainage
- Social issues: social disadvantage, fuel poverty issues, community regeneration and the importance of place
- Economic concerns
- Desire for best practice and good professional reputation
- Commitment by champions, e.g. chief executive of company engaging in environment and sustainability issues
- Corporate social responsibility
- Environmental management systems, ISO 14001
- BRE Homes Rating Scheme
- Stakeholder consultations
- Company environmental committees
- Risk assessment
- RES grant and other incentives
- Exploiting new markets and technologies
- The worldwide cement sustainability initiative

Sustainable development as a driver is very important in this sector, particularly amongst private and other (especially associations and networks) institutions where it is firmly on the construction agenda. Many public and private sector organisations exist specifically to deal with sustainable construction and environmental awareness in the industry. There is a proliferation of Government-related and independent organisations and networks designed to promote sustainable construction initiatives by researching, providing advice and guidance, and pioneering good practice in sustainable construction (The Sustainable Construction Task Group, 2002). Examples of other types of institutions are, the European Alliance of Companies for Energy Efficiency in Buildings (EuroACE), Global Alliance for Building Sustainability, the Institution of Civil Engineers, Royal Institute of British Architects (RIBA) and The Chartered Institution of Building Services Engineers (CIBSE).

The drivers for more sustainable construction practices come from stakeholder interests, government interests, legislation, funding bodies, etc. (see inventory). In the

private sector, concern for company image and reputation is a strong driver of good environmental practice and implementation of sustainable development measures. The inventory highlights that large construction companies in particular (e.g. Kier Plc., Costain Plc., Carillion Plc.) pride themselves as leaders in championing action on the environment and sustainable development. Hertin and Berkhout (2003) confirm that climate change in the construction sector is only one driver among many facing the industry, and that others include technical innovation, shifting consumer expectations and changing regulation. All of these are reflected in the examples we have compiled in this inventory.

The focus, in recent years, on mitigation issues (Hasegawa, 2004), can in itself be considered a driver of adaptation. Focussing on mitigation generates some degree of adaptive capacity because by thinking about climate change, this advances the preparedness of the industry to respond to the impacts of climate change. For example, the implementation of water efficiency schemes as part of sustainable design mean that new building stock is likely to be more prepared for water shortages in future dry summers than it might otherwise be.

The data contained in the inventory suggests that in the planning and construction sector, little change is undertaken in response to environmental issues on a voluntary basis and that legislation is necessary to push organisations to act. The Sustainable Construction Task Group (2003), for example, state that despite information and various legislations the industry has yet to realise its practical response to sustainable construction (not specifically adaptation). The report states that a common call is that legislation for sustainable construction is the only driver for change to the construction industry, and that changes will be brought through, for example, the Energy White Paper and Water Bill. Ultimately, Sorrel (2003) argues that as well as information provision, there is a need for integration and organisational change in the construction industry, and an integration of climate policy objectives into the reform agenda (see also Liso *et al.*, 2003)

3.3 Rural land use

Climate change will pose a significant challenge to this sector. There is some evidence to suggest that awareness of climate change and its impacts are generally high among practitioners and farmers in the UK, yet there is little evidence of individually planned adaptation to the impacts of climate change. In this sector there are a number of research programmes and emerging government guidelines that aim to address the long-term impacts of climate change. These actions are largely helping to build adaptive capacity, i.e. building up the knowledge about the likely impacts of climate change and appropriate responses needed. There also exist at different scales regulations and policies that are driving better land use practice, which might have adaptation co-benefits or act as entry points for projects and programmes to engage in adaptation measures. These include the reformed common agricultural policy (CAP), which encourages better land use management and agri-environment businesses. It is however too early to determine whether these actions will be effective or considered successful.

3.3.1 Biodiversity & Conservation¹⁴

Introduction

In practice it appears that this sector is at an early stage in adapting to climate change. There is a lot of capacity being built, for example significant efforts are being made by Central Government, Devolved Administration and their agencies to provide information, guidelines, and advice on how to adapt to climate change. This is illustrated by a good variety of outputs being generated, such as recommendations and advice, including improvements to the permeability of landscapes to facilitate rainwater dispersal, minimization of further loss of semi-natural habitats; identification and safeguarding of areas with good existing adaptive capacity, supporting new habitat creation, securing more effective targeting of agri-environment schemes, and translocation of species where necessary (English Nature, 2005). These outputs largely fall within existing policy

¹⁴ See Annex 4: Potential impacts of climate change on biodiversity in the UK

and legislative frameworks, and climate change is often considered one of many pressures on wildlife conservation and habitat protection. There are few examples of implementing adaptation actions, but these include a habitat restoration project in the fenlands which is one of the most ambitious restoration projects in the UK. It is a partnership comprising the Environment Agency, the Wildlife Trusts, Huntingdonshire, and English Nature which aims to restore 3000 hectares of fenland over 50 years. Meanwhile, there are many more examples of building adaptive capacity across all scales of institutions, but mainly in policies and organisations. The characteristics of adaptation are largely organisational and involve organisational-related changes, followed by about half that number of policy changes and an example of behavioural change in a Welsh organisation. In terms of scale, the inventory shows that that existing legislation across scales has implications for adapting to climate change.

Institutional adaptations

The Biodiversity & Conservation inventory encompasses 38 examples of adaptation. The majority of examples lie within the public sector, particularly concerning government Ministries and Departments. The inventory also contains examples of adaptations by government agencies, programmes, funded research institutes, regional agencies, devolved administrations and local authorities. Other examples relate to voluntary, community and NGO adaptations, and associations and networks. In this part of the inventory there are no examples of individual level adaptation (see Box 3.27 for examples of adapting institutions).

Box 3.27 Some of the institutions adapting in this sector include:

(Biodiversity / conservation)

Public

- Government Ministries and Departments, e.g., ODPM, Defra
- Government agencies, e.g., Countryside Agency, Environment Agency, English Nature,
- Government funded research institutions / programmes, e.g., UK Climate Impacts Programme and CEH
- Devolved Administrations, e.g., Scottish Executive, Welsh Assembly, Department of Environment Northern Ireland, Countryside Council for Wales, SEPA, Environment Wales
- Regional Government Agency, e.g., East of England Regional Assembly
- Local authority, e.g. Broads Authority

Other

- Community, voluntary and NGO, e.g., National Trust, the Royal Horticultural Society, the Royal Society for the Protection of Birds
- Associations and networks, e.g., London Climate change Partnership, The Land Restoration Trust, Springwatch, West Midlands Biodiversity Partnership Strategy

Adaptation outputs

There is a good variety of outputs being generated from the adaptation work occurring in these examples. There are not only reports being produced but there has been the establishment of partnerships, programmes and strategies, guidance and legislations, and research programmes. For example the MONARCH project (Cook and Harrison, 2001) (first phase complete and second ongoing) has produced models and other practical outputs for use by stakeholders to improve their ability to forecast and make recommendations about how climate change might impact wildlife and geological features.

Partnerships include Springwatch, a joint venture between the BBC, the Woodland Trust and the UK Phenology Network. This is the biggest ever survey into the arrival of spring across the UK, where the public can participate to build a complete picture to help scientists understand how spring is changing and what needs to be done to help wildlife thrive in the UK.

Classification of adaptation: Implementing adaptation actions and building adaptive capacity

There are two example of implementing adaptation actions in the inventory. One example is the Great Fen Project (see above). Examples of building adaptive capacity exist across all scales of institutions, but mainly in policies and organisations. For example, Regional Spatial Strategies (e.g. Yorkshire and Humber Assembly Regional Spatial Strategy Project Plane 2004, see Box 3.28) are the new system for regional land-use planning replacing the old regional planning guidance (RPG). The RSS' are vitally important because for the first time they will be legally binding documents which regional and local government will have to consider before making planning decisions.

Box 3.28 Yorkshire and Humber Assembly Regional Spatial Strategy Project Plan 2004

The RSS aims to comply with national guidance (Planning Policy Guidance 11) and it is hoped will support and link to other regional strategies and programmes that were not previously considered. The RSS has identified 18 topic areas of which **one is climate change**, which is mentioned **74** times in this document. The study concludes that a high quality RSS requires an overall understanding of a region's natural environment recognising its capacity for change, vulnerability to development, and opportunities to contribute to the other regional strategic objectives. This requires effective consultation and partnership, including working with neighbouring authorities at sub-regional level and neighbouring regions and a good understanding of the regional context.

Characteristics of adaptation

Out of a total of 38 examples across public and other organisations (no examples in the private sector) the characteristics of adaptation are largely organisational (25). 12 examples are policy related and one behavioural. Organisations such as Countryside Council for Wales (the Government's statutory adviser on sustaining natural beauty and wildlife in Wales) are adapting in both organisational and behavioural ways. It claims to be the first organisation in the UK to invite its entire staff to take a closer look at climate change, what is causing it, and how to help to tackle it (both mitigation and adaptation).

At the policy level UK Government and its implementing agencies are building adaptive capacity by making significant efforts to provide information, guidelines, and advice on how to adapt. These include the Environment Agency in England and Wales, and the Scottish Environment Protection Agency in Scotland. As mentioned in Wales, the Countryside Council for Wales (CCW) is taking a lead on addressing adaptation, but they themselves are looking for advice on how to do this in practice.

The vast majority of the examples cited are in the public sector (either directly carried out by individual departments or funded by them). The only other adaptation examples are by associations and networks – some which have government involvement, for example the London Climate Change Partnership which has produced a London Climate Change Study addressing biodiversity as an option for flood defence and the development of green corridors for species migration.

Scale of adaptation

Biodiversity & Conservation in the UK is administered by international, national, regional and local legislation, conventions and obligations. These include protecting and conserving internationally and nationally designated sites, and meeting land-use planning and other legislative obligations. At the regional and local level there already exist an array of strategies e.g. Local Biodiversity Action Plans, as well as in the range of other plans, programmes and strategies. At the local level these plans set out

priorities for local areas. However, in terms of adaptation, the majority of action appears to be occurring at the national level.

There are 25 examples at the national scale, six in the Devolved Administrations, four regional, three local and zero individual. The local examples of adaptation includes the Broads Authority (Norfolk) which has produced a Broads Plan (2004) a long term strategy based on a long-term vision consistent with a local flood alleviation project, and considers major issues such as climate change (Green and Conti, 2004). Regional examples of adaptation include efforts by the West Midlands Biodiversity Partnership Strategy, which aims to improve understanding of the impacts of climate change on the biodiversity of the region, undertake activities to mitigate its effect, and to develop adaptation strategies. At the devolved scale the Scottish Executive has produced a Scottish Biodiversity Strategy (Scottish Executive, 2004b) which identifies the challenges to biodiversity posed by climate change, and emphasises the importance of planning to increase the connection between areas of habitat to help species to shift their range in response to climate change. At the National scale the ODPM has produced the UK Biodiversity Action Plan setting out the framework for national and local action to support biodiversity. At the European scale there is one example, which is the EU Habitats Directive (EU, 1992). This is a major European initiative on protecting biodiversity through conservation of natural habitats.

There are examples occurring at a range of geographical locations ranging from one example from Europe, 22 examples at the UK level, 7 in England, 3 in Wales, 3 Scotland, and one in Northern Ireland, and the rest in Norfolk and Suffolk. For example, in Scotland the Scottish Environment Protection Agency (SEPA) (the public body responsible for environmental protection in Scotland) is making efforts to monitor and support good land quality.

Purposefulness of adaptation

There are 12 examples of unplanned adaptation which are largely at the policy and organisational scale. These include: the ODPM Regional Spatial Strategies, and planning guidance note on biodiversity, Defra's Environmental Stewardship Scheme,

Defra's Country Stewardship Scheme (see Box 3.29), and Defra's England Rural Development Programme, which consists of schemes to conserve and improve the rural environment. Defra's England Rural Development Programme (ERDP) for example, includes schemes to conserve and improve the rural environment, or land-based schemes (including agri-environment schemes), and schemes to help farming, forestry and other rural businesses and communities to adapt to changing circumstances and to develop projects. According to figures published by Defra (2005c) existing agri-environment schemes have helped to stabilise the long-term decline in farmland birds. It is an example of unplanned adaptation because it helps farming, forestry and other rural businesses and communities to adapt to changing circumstance, but not explicitly to climate change.

Box 3.29 Example of unplanned building adaptive capacity in biodiversity / conservation sector

Land management under Defra's [Countryside Stewardship Scheme](#) has been shown to benefit several previously declining bird species including Cirl Bunting, Stone Curlew and Grey Partridge. The Scheme pays farmers and land managers to improve the natural beauty and diversity of the countryside. Countryside Stewardship currently has over 16,000 agreement holders. The Countryside Stewardship Scheme closed to new applications in 2004. While existing CSS agreements will run their course, the scheme has been replaced by the new Environmental Stewardship Scheme (ES), which is intended to build on the recognised successes of CSS and the Environmentally Sensitive Areas (ESA) scheme. (Defra, 2005d)

The remaining 25 examples are of planned adaptation. These include, in the public sector, the Environment Agency, which states its major role in limiting the scale of climate impacts by adapting to climate change in the biodiversity and land use sector, e.g. protecting wetland habitats and species, and building climate change into catchment management plans. Another example of an organisation that is implementing planned adaptation actions is the Royal Society for the Protection of Birds, which is creating a valuable reed-bed habitat in Norfolk for migrating bird species due to the predicted loss of such habitats in coastal zones across East Anglia due to climate change.

Drivers of adaptation

The main driver behind adaptation in these examples is biodiversity and conservation. In some cases extreme events such as the storms of 1987 and floods and droughts have had a role in the driving forward of adaptation. The impacts of the Common Agricultural Policy on land management, is also a significant driver. Some further explanations of the drivers given in the literature are presented in Box 3.30).

Box 3.30 Drivers of adaptation in the rural land use sector (including biodiversity / conservation aside from climate change and the impacts of the CAP)

- Regulations, conventions, directives and legislation
- Development pressures, such as growing populations
- Sustainability
- Habitat Management and restoration
- Corporate Social Responsibility
- Dereliction of land

3.3.2 Agriculture & Forestry¹⁵

Introduction

Looking for adaptations in the rural land-use sector has highlighted that we are still at an early state in the adaptation process. It is much easier to find unplanned adaptations than planned adaptations and most planned adaptations fall into the category 'building adaptive capacity' rather than 'implementing adaptation'. There are a large number of research projects and studies that are generating reports, guidelines, and advice. These are beginning to impact on policies, regulations, schemes and so on. There remain relatively few published examples of individual implemented actions.

This may underestimate the actual extent of implementation. Some of these schemes and regulations (such as the Countryside Stewardship Scheme) are already affecting individual land-owners' actions, albeit individuals may be responding to the scheme requirements or regulation rather than considering climate change per se.

¹⁵ See Annex 5 for more information on the agriculture and forestry sectors.

Generally, however it probably reflects a feeling among individual farmers particularly that (a) they have more urgent short-term problems, and (b) that the actual impacts are still too poorly/unreliably defined to make immediate adaptation sensible and (c) that they can react to change as it occurs. Arguable the land-owning organisations are taking a more pro-active view, at least in building adaptive capacity.

We now turn to explore the details of this sector.

Institutional adaptations

The Agriculture & Forestry inventory encompasses 34 examples of adaptation. Half of these examples are within the public sector and the other half concern other adaptations, voluntary, community and NGO adaptations, associations and networks, and some examples of individual level adaptations. Some of the institutions adapting in this sector can be found in Box 3.31.

Box 3.31 Institutional drivers in the rural land use sector

Public

- Government Ministries and Departments, e.g., Cabinet Office, Defra
- Government agencies, e.g., English Nature, Forestry Commission
- Government funded research institutions / programmes, e.g., Tyndall Centre
- Devolved Administrations, e.g., Scottish Executive, Welsh Assembly
- Regional Government Agency, e.g., East of England

Other

- Community, voluntary and NGO, e.g., Farmcare Farming and Wildlife Advisory Group, The Woodland Trust
- Associations and networks, e.g., National Park Authorities, National Farmers Union
- Individual, e.g. Collin Coward farmer.

Adaptation outputs

There is a good variety of outputs being generated from the adaptation work occurring in these examples. There are not only reports being produced but there has been the establishment of forums, training, information exchange, management change, equipment change, schemes, research, strategies, partnerships, awards, award winners and legislation (e.g. Water Act 2003) (Defra, 2003). For example the creation of the 'Rural Climate Change Forum' by Defra in 2005 (Defra, 2005e), which has been designed to tackle climate change issues in rural areas. It will inform policy development and research. The Scottish Forestry Strategy is an example of the Scottish Executive's serious efforts to tackle climate change. An example of research is the Institute of Grassland and Environmental Research (IGER) which has been conducting research projects addressing the potential effects that climate change might have on agriculture and the wider environment.

Classification of adaptation: Implementing adaptation actions and building adaptive capacity

There are 8 examples of implementing adaptation actions in this part of the inventory. These include a farmer who won the Farming for Wildlife Award, other farmers who have won various awards, and an individual who has switched to growing stone fruit in response to a warming climate. The Woodland Trust's 'Tree for All' is replanting 12 million trees between 2004-2009 through the community to protect the environment from the impacts of climate change, and modern development pressures.

Another example is of Abstractor Groups, which are area-based informal groupings of irrigation abstractors. A survey of 500 irrigated farms within the Anglian region found 16 percent were already active within a Farmer Organised Abstraction Groups (FOAG) and 33 percent of non-members were keen to join one. Successful groups include BAWAG in the Norfolk Broads, ESWAG in East Suffolk and the Lark Valley Abstractors in West Suffolk (Rudge and Gowing, 2004; Hammett, 2005)

Examples of building adaptive capacity (25 examples) include Defra's Environmental Stewardship Scheme (2005d) where farmers will be able to earn payments for undertaking environmental protection, e.g., by maintaining hedgerows. This scheme is intended to build on the recognised success of the Environmentally Sensitive Areas Scheme and the Countryside Stewardship Scheme. It also has objectives for genetic conservation and flood management.

Other examples are provided in Box 3.32

Box 3.32 Examples of building adaptive capacity

Another example of building adaptive capacity is the East of England Study by the East of England Regional Assembly (2004), which stresses adaptation to water resources pressures, noting innovative ways of managing water. The National Farmers Union is also building adaptive capacity by improving the efficiency of water use in the farming and food by an Initiative for farmers in the East of England which included a series of farmer workshops promoting efficient irrigation industry.

Characteristics of adaptation

Out of a total of 34 examples across public and other organisations (no examples in the private sector) the characteristics of adaptation are largely behavioural (12) followed by organisational (11), ten examples are policy related (see Box 3.33) and four are both organisational and behavioural.

All of the behavioural-related changes are also examples of implementing adaptation actions (see inventory). An example is Andy and Sue Guy of Thorney Abbey Farm who won the Wilkinson Nottinghamshire Environment Award in 2005 for growing alternative crops, and working with the RSPB, maintaining hedgerows and growing complementary crops to avoid the need to use fertiliser.

An example of organisational change is the Country Land and Business Association which produced a report in 2001 outlining over 100 responses concerning the effect of climate change on rural business in the rural economy and adaptations to climate change (CLA, 2001), raising specific issues for farming include flooding, water supply and soil management, and identifying the need for more coordinated action across government agencies. The Biomass and Renewable Energy Project Staffordshire was set up in 2003, working with a farmers cooperative and research institutions, to look at ways in which farmers could diversify into new crops, specifically *miscanthus* (elephant grass) to be used as an alternative source of fuel (Roberts, 2005).

Box 3.33 An example of policy related adaptation

An example of policy related adaptation is the Forestry Commission's report entitled 'Woodlands for Wales' (2001). It notes that Wales must consider how robust its woodland habitats are, actions include increasing the area of native woodlands, and increasing corridors and links with fragmented woodlands.

Scale of adaptation

At the administrative or management scale 16 examples are at the national scale, five examples from the Devolved Administrations, one regional (see Box 3.32), five local, and seven individual.

The local examples of adaptation include the Wilkinson Award for Dairy Conservationists in Nottinghamshire which rewards conservation work on commercially run farms in the county. Regional examples of adaptation include efforts by the East of England Regional Assembly which stresses in its East of England Climate Change Impacts Study (2004) the need to adapt to water resources pressures. The Ulster Farmers Union is an individual example from the Devolved Administration where the former President of the Union runs an agribusiness that has won awards for innovation and environmental advances in its farming practices. At the devolved scale the Scottish Executive has produced a 'Forward Strategy for Scottish Agriculture and the Prevention of Pollution from Agricultural Activities' (2001) which gave commitment to review climate change research and involved the farming industry (Scottish Executive, 2001). At the National level, the government agency English Nature has set up a 'Farming for Wildlife Award'. The Forestry Commission (2002) report entitled 'Climate change: impacts on the UK forests' has standards that relate to the UK Forestry Standards intended to guide the practice of sustainable forestry (Broadmeadow, 2002).

There are examples occurring at a range of geographical locations ranging from 8 examples at the UK level, 6 in England, 4 in Wales, 2 Scotland, and one in Northern Ireland, and the rest in regions and local areas. For example, at Hall Farm in Lincolnshire winner of the 2004 Farm Care Silver Lapwing Trophy, the UK's most prestigious farm conservation award.

Purposefulness of adaptation

There are 21 examples of unplanned adaptation and 14 planned examples. Unplanned adaptations include: wildlife and conservation initiatives which do not explicitly address climate change but environment more generally, e.g., Defra's Environmental Stewardship Scheme, and The Water Act (2003) (Defra, 2003), which could create business opportunities for irrigators to trade water, invest in water saving and so on. Unplanned adaptations also include the fact that trickle irrigation, which promises lower water use, has expanded to cover 5% of the irrigated area in England and Wales (Environment Agency, 2001) and reports by farmers in 2001 that over 50% of the

irrigated area in England is now scheduled by scientific methods (Weatherhead and Danert, 2002).

An example of planned adaptation from the forestry sector is the National Park Authority for the New Forest has a New Forest Committee Strategy since 2005, which includes a substantial section on the impacts of climate change, including impacts on the coast. It states that current conservation management practices will need to be adapted sustainably through, for example, coastal habitat management plans (for further information see inventory).

Drivers of adaptation

The drivers behind adaptation in these examples are mixed between responses to climate change itself and other drivers. In some cases responses to the impacts of climate change include water constraints caused by drought, flooding events, and wind storms had a role in driving forward adaptation. The prospect of sea level rise is also a concern. The impacts of the EU Common Agricultural Policy on land management is a significant driver. Some further drivers given in the literature are outlined below (Box 3.34):

Box 3.34 Drivers of adaptation in the rural land use sector

- Sustainable development sparked by foot and mouth disaster
- Biodiversity and conservation
- Regulations such as the EU Habitats Directive
- Water shortages
- Crop yields and quality benefits
- Water saving
- Soil conservation
- Opportunities, e.g., the move to robust energy crops, mitigation opportunities
- Financial, costs of production, integrated farm management
- Sustainable forest management standards
- Impacts on habitats
- Climate change
- Common Agricultural Policy

3.4 Transport¹⁶

Introduction

Most of the adaptations to climate change in the transport sector are occurring in public institutions. However, there are also some private sector adaptations underway connected with both the rail and road networks. The sector demonstrates a wide variety of adaptation outputs including management plans, various actions, workshops and research into the potential impacts of climate change and adaptation options. Most of the examples are of building adaptive capacity, with a very small minority of examples demonstrating the implementation of adaptation actions – these are occurring in both the public and private sector. Most of the examples are organisational examples of adaptation, rather than policy or behavioural indicating that much adaptation is taking place within the operation of the industry rather than at a national policy scale for example. Indeed, most of the adaptations given as examples in this sector are planned in response to a need to adapt to climate change, and most of the drivers of adaptation are directly related to climate change and its impacts (both experienced and projected for the future). This indicates that institutions in the transport sector are responding directly to the risks that climate change poses for the industry. Adaptations are operating at a range of administrative scales, particularly at the national scale in England and the Devolved administrations. There are few examples of smaller scale adaptations.

Institutional range of adaptations

There are 22 examples of adaptation in this sector, mostly occurring in the public sector. There are some private and one other type of adaptation (listed under ‘Associations and networks’). Some examples of institutions adapting to climate change are presented in Box *.

Most of the examples identified concern mainly the rail industry within the transport sector, although adaptation to climate change for the road network is also represented.

¹⁶ See Annex 6 for more information of the potential impacts of climate change on the transport sector.

Box 3.36 Examples of institutions adapting in the transport sector

Public

- Government Ministries and Departments, e.g., ODPM, Department of Transport;
- Government agencies, e.g., Highways Agency, Strategic Rail Authority, Network Rail;
- Devolved Administrations, e.g., Scottish Executive, SNIFFER, National Assembly for Wales, Scottish Environmental Protection Agency;

Private

- Private, e.g., Railtrack Scotland, Railtrack, Rail Safety and Standards Board, National Express Group plc.

Other

- Associations and networks, e.g., Sustainability West Midlands;

Within the public sector, adaptations appear to be happening in Government ministries and departments, Government agencies and in the Devolved administrations but not in other types of public institutions. An example of a Government Agency adaptation is The Highways Agency. The Agency notes in its 2005-6 business plan that the Agency will be taking forward a programme of work connected with climate change – not only concerning greenhouse gas emissions reduction but also the responses required for adaptation to the projections of climate change over the next 30 to 40 years. Network Rail's Safety and Environment Plan (2003) sets out the company's plans for risk control, reduction of business loss, and how to improve safety performance. Adverse weather is noted as a hazard for the rail network and the document states that Network Rail plan to introduce a strategy to increase the resilience of the railway infrastructure to high winds, flooding and extreme temperatures – stating that this includes undertaking research into the long-term impacts of climate change and making recommendations to address it.

Adaptation outputs

The outputs included in the inventory represent a wide range including, programmes and reports, policy, white paper, design manual, initiative, research, statement, management plan, safety and environment plan, action, business plan, workshop, and guidance for local authorities.

The design manual is The Scottish Executive's design manual for roads and bridges (such structures must conform to design standards included in the manual). It specifies that the design of new roads in flood plains should investigate the constraining effect of the road and bridges against conditions (for example, extreme events relating to climate change) that are exceeded on average once every 100 years.

Classification of adaptations: Implementing adaptation actions and building adaptive capacity

There are three examples of implementing adaptation and 19 of building adaptation capacity. The three implementing adaptations are split across public and private sector. For example, Railtrack Scotland, which is identifying sites vulnerable to flooding and installing pumps and culverts. Railtrack Scotland also works with the National Farmers Union to encourage actions on land adjacent to rail tracks to reduce risk of flooding. The Scotland and Northern Ireland Forum for Environmental Research (SNIFFER) highlights that the Northern Ireland Railways Co. Ltd (NIR) is strengthening coastal defences by restructuring some of the stretches of the Larne line in Northern Ireland (Smyth et al., 2002). The Strategic Rail Authority is upgrading infrastructure and is closely involved with the current multi-billion Pound upgrade of the West Coast mainlines infrastructure and signalling. All three examples are of planned adaptation to climate change.

Characteristics of adaptations

One example is policy-related, 21 are organisational-related and no examples of adaptation are occurring from a behavioural perspective in the transport inventory. The National Assembly for Wales is the policy example (see Box 3.37).

Box 3.37 The National Assembly for Wales – a policy example of adaptation to climate change

The National Assembly for Wales has an integrated transport policy, which builds on the Welsh transport policy statement 'Transporting Wales into the Future' (Welsh Office, 1998). It is an example of unplanned adaptation to climate change (building adaptive capacity), which aims to develop a safe, efficient, clean and fair transport system. It delivers integration between different types of transport, with the environment and with land-use planning, integrating and supporting the policy aims of education, health and wealth creation. Through local transport plans driven by the Welsh transport policy, the principle of sustainable development is addressed as well as action on local air quality and climate change, issues of accessibility and social exclusion, achieving a balance between dealing with congestion, meeting obligations under the Road Traffic Reduction Act 1997, and supporting economic development.

An organisational example is the Department of Transport (DfT), which produced a report called the 'Changing Climate: its impact on the Department of Transport' (2004) setting out the key impacts that climate change could have on transport. The key areas are road and rail, but the report also addresses aviation and shipping. It makes recommendations to ensure that DfT and other institutions in the transport sector are prepared to take action on preparing for the impacts of climate change. The DfT also ran some workshops with key stakeholders in the transport sector in 2004 to address the impacts of climate change (these are also included as entries in the inventory). The Network Rail Management Plan (2005) also addresses climate change and includes points about how to manage future risks (see Box 3.38 for more details). In the private sector the National Express Group Plc. notes in its corporate social responsibility report (2004) the challenge brought by climate change for the road network.

Purposefulness of adaptation

There are 16 examples of planned adaptation and six of unplanned in this sector. Planned adaptations include examples relating to the following institutions: The Rail Safety and Standards and Network Rail, see Box 3.38.

Box 3.38 Some examples of planned adaptations within the transport sector

- **The Rail Safety and Standards Board** leads and facilitates the railway industry's work to achieve continuous improvement in the health and safety performance of the railways, thus reducing the risk to passengers, employees and affected public. It has commissioned new research on into the, 'Implications of weather extremes and climate change on railway infrastructure'. This project will investigate the anticipated changes over the next 30 years, based on scientific evidence and informed opinion, and will assess the potential effect this will have on the railway infrastructure. It will then develop working assumptions of the overall effect of climate change over the next 100 years. Best practice and lessons learnt from other industries and railway organisations will also be considered along with the impact of extreme weather conditions over the last five years. This project will provide a better understanding of the likely effects that climate change could have on railway infrastructure. This will facilitate, among other things, appropriate component and track structure design. This follows a previous project on engineering aspects, entitled, 'Safety implications of weather, climate and climate change' (2003).
- **Network Rail** (the operator of Britain's rail infrastructure) is committed to climate change adaptation. This is reflected in two documents in particular: its Safety and Environment Plan (2003) and Management Plan (2005). The former sets out company's plans for risk control, reduction of business loss, and how to improve safety performance. Adverse weather noted as a hazard for the rail network and the document states that Network Rail plans to introduce a strategy to increase the resilience of the railway infrastructure to high winds, flooding and extreme temperatures. This includes undertaking research into the long-term impacts of climate change and making recommendations to address it.

Unplanned adaptations generally relate to making the transport sector more sustainable or actions towards emissions reductions and climate mitigation, not adaptation. For example, one of the Railtrack examples in the inventory and the Highways Agency 'Building Better Roads - Towards Sustainable Construction' (2003). This document demonstrates plans areas of: management of natural resources; reducing energy consumption; reducing emissions; landscape, townscape and heritage; biodiversity, respect for people; partnerships with better business. Climate change is mentioned in the context of reducing emissions but not adaptation. Building capacity to adapt by incorporating the issue of climate change and other sustainable development initiatives is considered as an unplanned adaptation because there are adaptation co-benefits.

Scale of adaptation

There are 10 national, 8 examples from the Devolved Administration, and 4 regional. The regional examples are initiatives being carried out by the Strategic Rail Authority

and Network Rail. In terms of geographical location the inventory tells us that most adaptations are taking place across the UK, in particular in England, Scotland and Wales.

Drivers of adaptation

In this sector drivers include climate change and climate related events, such as flooding, land slides, severe rainfall resulting in drainage problems, speed restrictions and line closure and other environmental risks to the network. Additional drivers are summarised in Box 3.39.

Box 3.39 Drivers of adaptation in the transport sector, aside from climate change related drivers

- Efficiency gains
- Sustainable development
- The need to minimise emissions
- The need for environmental strategies to deal with risks
- Regulation including EU SEA Directive

3.6 Summary

This section has presented an overview of the inventory. It has presented each sector in turn and considered the data as presented in the inventory.

Clearly there are many adaptations which are occurring in the UK, and the degree to which they are occurring is influenced by the sector. The water sector, particularly the water supply sector, is leading the game, with both the private and public sector engaging in adaptation actions. It is not clear however what has made the water sector make such large advances in its preparedness, while other sectors, such as transport lag so far behind. Both sectors require large physical capital investments, and hence it would suggest that both require consideration of factors that would affect long term, large capital investments. Perhaps this is because in the water supply sector the initial adaptations were policy changes, whereas in the transport sector the adaptations have been largely organisational.

We did not expect the other sectors with less need for large-scale capital investments to be undertaking long-terms horizon planning. This could explain why the agriculture and forestry sectors and the construction sector are further behind in their planning for climate change. Adaptations can be made relatively quickly and in a few years a climate change response can be implemented. This may not necessarily be an appropriate response, but it might explain why fewer adaptations appear to have occurred yet in these sectors.

We are unable to make any conclusive remarks about the voluntary, community or NGO adaptations, largely because if they have been undertaken, they have not been documented in a manner that has allowed us to find them.

Overall, the focus on building adaptive capacity has been shown to be important in all sectors, and the role of the UKCIP cannot be underestimated in this regard. Implementation of adaptation actions seems to occur when a certain momentum has built up, either in the private or the public sectors.

4. Understanding adaptation in practice in the UK

4.1 Introduction

In this section we present our thoughts on adaptation in practice in the UK. We reflect on the data presented in section three and revisit the definitions set out in section one.

The inventory shows that there are a range of adaptations taking place in the UK across sectors and institutions in a broad variety of ways. Within each sector that we investigated, adaptation is clearly happening yet each sector is at an 'early stage' in terms of implementing adaptation actions.

The majority of examples in the inventory were found in the public sector. Most are contributing to the creation of adaptive capacity, which should assist companies and government at a later stage to be able to respond to the impacts of climate change. This 'capacity' appears to emerge through a process of learning about the potential impacts of climate and adaptation options, and it is an important first step before actions can actually be implemented. Actions that are considered implementing adaptation examples tend to be one-off projects or activities by certain institutions (e.g. the Environment Agency which has a mandate for flood protection) and private firms in the water sector. The examples of adaptation that have been collected are driven by a host of factors ranging from personal motivations, response to regulations, sustainable development standards, and financial pressures. There are clearly many drivers of change within each of these sectors that are complex, inter-related and often hard to identify. Waiting on climate change to drive change in UK institutions in the private and public sector may not be advisable either in terms of precaution, or in terms of the reality of what drives change in companies and government. Other drivers of change need to be exploited to encourage adaptation today. It must be remembered that one size does not fit all, and greater understanding of the reality of change in the various sector at different scales must be factored into any change management process. Our

research in compiling the inventory suggests that climate change adaptation in the UK will have to be built into existing policy frameworks.

This section endeavours to answer some of the questions that underpinned this project: What type of adaptation is taking place? Where are the adaptations taking place? What is driving adaptation?

4.2 What type of adaptation is taking place?

This section addresses the way in which adaptation is taking place, whether it be building adaptive capacity or implementing adaptation actions. It discusses the data presented in section three and discusses the implications of these. This section also discusses the purposefulness of adaptations, i.e. whether they are planned or unplanned, and what this means for adaptation in the UK.

4.2.1 How is it occurring?

The inventory shows that there exist more examples of building adaptive capacity than of implementing adaptation actions across all sectors. The sectors are building adaptive capacity in different ways, for example in the construction and water sectors, organisations are building adaptive capacity via the adoption of sustainable development initiatives, particularly in the private sector. In the transport and biodiversity / conservation they are reacting more directly to the threat of climate change by focusing on research into the impacts and looking for ways to improve or change management practices accordingly. In the water sector, building adaptive capacity is observed as water efficiency campaigns which are driven by physical water shortages and legislation, in particular the Water Act 2003 (Defra, 2003) and the EU Water Directive (EU, 2000). Implementing adaptation actions are occurring as one off examples in each sector.

Although there are few examples of adaptation actions being implemented the importance of building adaptive capacity (understanding the impacts of climate change

on institutions and the options that they have to respond) must not be underestimated. This is possibly the most important stage at which the UK public institutions can take the lead to extend that capacity. Planned adaptive capacity building however requires sufficient resources, such as the provision of networks (e.g. links with UKCIP) and financial incentives (e.g. for local authorities to develop plans specifically addressing climate change impact at their local level).

The reason that the majority of examples are of building adaptive capacity is attributed to uncertainty of the future climate change impacts that might be expected, in particular at local scales. Many of the examples are of research that has been or is being carried out to investigate these impacts and what the options for adaptation might be. A further explanation might concern the time-scales on which most institutions operate. While climate change is a long-term problem, most institutions are faced with short-term pressures, both in the public and private sector. At the highest level of decision making in the public sector the ground work is starting to be laid e.g., the UK government's Sustainable Development Strategy (Defra, 2005a) which highlights the need to adapt to climate change as a key issue for the nation.

4.2.2 Is it planned or unplanned?

Most of the examples are planned adaptations rather than unplanned. Planned adaptation examples include those which have highlighted climate change as a driver. Still, it is noticeable that for many of the planned adaptations, climate change is only one of many stated drivers, often a minor one.

Unplanned adaptation to the impacts of climate change often seems to be the result of a 'side-benefit' of an action or decision taken for other reasons. One prime example of an unplanned adaptation to climate change is the Thames barrier, which was originally constructed, following the 1953 floods, to protect London from tidal flooding. At that time climate change was not of any influence on the decision to invest in the project. This example illustrates that decisions taken at one point in time might coincidentally also

have adaptation benefits. Given the uncertainty of climate change impacts particularly at local scales the question of successful adaptation is of key importance.

In the land use sector, there are few examples of planned adaptation to climate change across the UK. There exist a small number of *ad hoc* examples of farmers and voluntary initiatives to improve farming practices, largely driven by sustainable development policy at the local and regional levels. The information on the impacts of climate change is at best uncertain and there is limited representation of farmers in important decision making processes. Information about the impacts of climate change is not sufficient incentive to promote general adaptation. Some individuals will be motivated to take action, simply on the basis of information provision, and will lead by example, such as the farmers in Pont Bren. Others might wait for more information, for legislation, for resources or for a sea change in behaviour among competitors before they act.

Government policy clearly influences the way in which companies respond to climate change. In developing new policies which may or may not be related to climate change or climate impacts, the government must consider the implications of the policy change and how this will affect the potential for successful adaptation. When developing new policy, government must consider: what types of adaptation the new policy or organisational change will promote. For example, will the change generate specific climate change adaptation actions by individuals and groups in government and the private sector or will it drive change that could have created additional benefits, such as an adaptation to climate change?

We cannot advise the government on which actions or policies it must take – as all actions the government takes will affect the capacity to adapt. The implication of this is that any policy change by government must be evaluated for its effect on individuals or groups ability to adapt to climate change. This cannot be taken through any statutory body as the volume of work of such a group would be enormous. The only way to ensure that this thinking can be applied is if each government department acknowledges that any decision or action it takes can affect people's ability to adapt.

The concept of climate change adaptation needs to be fully incorporated into the institutional culture of the government and other large bodies that have the power to affect others' ability to respond to climate change.

4.3 Where are the adaptations occurring?

This section addresses where adaptation is occurring, whether it in public or private or other institutions. It discusses scale of the adaptations, focusing in particular on the administrative and management scales at which they are taking place. The section refers to the 'institutional and analysis and development' conceptual framework (Ostrom, 1990) outlined in section one.

4.3.1 Institutions

The inventory shows evidence of adaptations occurring in different types of institutions, public, private and other types e.g. community-based. Adaptations were most observed in the public sector in England and the Devolved Administrations, particularly in Government Ministries and Departments and their agencies (e.g. the Environment Agency). For example, the non-specific inventory illustrates that across the UK strategies, programmes, policies and legislation are increasingly addressing the impacts of climate change, for instance, the Water Act 2003 (Defra, 2003) requires water companies to consider water efficiency as a factor. Policy related and organisational related changes that consider adaptation were more commonly found than evidence for behavioural change. In other institutions, such as community-based or small farms in the rural land use sector, for example, behavioural change was more common than in other sectors.

4.3.2 Scale and location

In the inventory we addressed adaptation to climate change at different scales of administration or management, and geographical location. Across sectors we have looked for evidence of adaptation in central government, regional and local authorities and so on. In the private sector, we included large and small firms and individuals.

Most adaptive capacity building is taking place largely at the national scale, e.g. in national government policies and programmes. In the construction sector, although there exist national policies, programmes, associations and networks that provide advice and directions on how to address climate change, this information does not appear to be filtering down to the private and individual level.

During the process of inventory compilation, the importance of EU Directives and their impacts on UK climate (and other) policy became apparent, and it became clear that these regional initiatives indirectly contribute to adaptation in particular in the rural land use and water sectors. In the rural land use sector the Common Agricultural Policy has had significant impacts on the UK. Biodiversity and conservation in the UK is largely driven by the EU Habitats Directive (EU, 1992) and various constitutional and statutory orders. Yet, there is increasing awareness among government, government agencies and devolved administration regarding the need to link climate change with biodiversity conservation. Several important projects, such as the MONARCH1 and 2 have highlighted this important link (Cook and Harrison, 2001). A great deal of advice and information is being provided by the central to the periphery organisations and public bodies, it is less clear however, as to the numbers that are applying these recommendations. Again, it is early days and will require monitoring and evaluation to understand the impacts of building adaptive capacity in this area.

Climate impacts are spatially varied as highlighted by the work of UKCIP. Location matters as to where adaptation is happening and the type of adaptation, which will depend on the geographical and the social structures in that place.

The water sector inventory shows, for example, that across the UK there is different water availability and demands. In those locations experiencing shortages, notably the South East and South West, local authorities (e.g. Hampshire County Council which is part of the South East Climate Change Partnership) and small and large water companies are engaging in water efficiency efforts through water efficiency campaigns

(e.g. Anglia Water and Plymouth Water) in efforts to encourage customers to use less water. These companies are driven by the need to maintain water supply to their customers, prices and regulation.

Gathering from the UKCIP reports and anecdotal evidence on the devolved administrations, it appears that the Scottish Executive has taken a lead on addressing adaptation to climate. The Welsh Assembly and the Northern Ireland Assembly have more recently begun to engage more seriously in the matter however. For example, the DOE of Northern Ireland is currently working with SNIFFER to update the previous impacts scoping study. In the past year it has also produced a climate change indicators report, and a guidance document for public bodies. It continues to work closely with UKCIP in promoting awareness of climate change impacts and adaptation in Northern Ireland). More recently the re-establishment of SNIFFER (Scotland and Northern Ireland Forum for Environmental Research) also illustrates a UK wide commitment to collectively address climate change (Harrison *et al*, 2001).

The UKCIP regional studies provide detailed information on the issues that matter to the different regions and devolved administrations. The Scottish Executive for instance, highlights housing as a priority area since with climate change impacts, poor housing will result in increased dampness and worsen health impacts with climate change. Scotland is also particularly concerned with the impacts of climate change on the landscape and issues of flooding (Kerr and McLeod, 2001). Wales is also concerned about water quality, flooding issues, and biodiversity conservation (Welsh Assembly, 2001). Northern Ireland has more recently listed adaptation proposals that include management and monitoring of biodiversity, more holistic approaches to nature conservation, a more diverse farmed landscape, crop diversity such as hemp, willow and biomass, and mushroom production (DoE, 2002). On transport the Northern Ireland Assembly is mostly concerned with ferry links and impacts on coastal ports (Harrison *et al*, 2001).

In the UK regions the northwest is expecting to see changes to the landscape and pollution to water courses. Workers are likely to experience heat stress in buildings not designed for a warmer future. In the southeast people are vulnerable to flooding and drought and structural problems associated with clay based soils, as well as increased pest and disease. Meanwhile the South West is estimated to suffer the impacts of sea level rise and associated coastal erosion, as well as toxic sediments in estuarial waters and risk to transport infrastructure (www.2glos.ac.uk/cccf/report/session2.htm Accessed 4/4/05) .

In summary, the adaptation priorities and options seem to depend on both the biophysical geography (e.g. risk of flooding, drought) and socio-economic and governance system (e.g. devolved administrations). This needs to be taken into account in planning for adaptation. Each location might require different action plans and resources to address adaptation.

4.4 What is driving adaptation?

This section identifies the drivers of adaptations and the problems associated with these.

The inventory shows that there exist a large number of drivers, and that these are not always directly related to climate change. Building adaptive capacity is often associated with indirect drivers such as sustainable development policies, regulations and corporate social responsibility and ISO standards. There also exist a large number that are directly driven by climate change related events, i.e. drought, flooding.

In compiling the inventory it became clear that identifying the drivers of change was often impossible. In particular the difficulties we have encountered are:

- The drivers of adaptation are generally complex and mixed, e.g. the British Cement Association, which notes that action on climate change is driven by its engagement in the World Wide Cement Sustainability Initiative, climate change

levy, corporate social responsibility, and its environmental management system and ISO.

- Drivers may not be directly climate related but actions are worth doing anyway, e.g., adaptations by the construction industry make sense under their existing sustainable development policies or adaptations in the rural land use sector (as a result of CAP).
- Many drivers of adaptation are not climate related, even though climate may appear to be a driver. For example, adaptation may be driven by climate change related regulations, but not by climate change itself. For example, demands to mitigate (e.g. climate change levy) are driving actions which are leading to the building of adaptive capacity or which can be considered as unconscious actions to implement adaptation (e.g. water efficiency).
- A lot of events such as flooding, storms and other extreme events are noted as drivers. Whereas experts may see these as indications of climate change being a driver, institutions and individuals do not necessarily perceive them as climate change. For example, flooding is perceived by some as a problem of building on floodplains rather than an indicator of climate change. A lot of the adaptation examples in the water sector are driven by flooding but are unplanned in a climate change context because the flooding event is unrelated to climate change. At the institutional level, this has also been found in research at the level of individual perceptions (Whitmarsh, 2005)

4.5 Revisiting the definition of adaptation

In section one of this report we outlined a definition of adaptation which was very broad and very general:

The action or process of adapting, fitting, or suiting one thing to another.

This definition includes deliberate actions and unknowing actions; it includes actions taken in anticipation of or in response to a stimuli (that can be a climate change impact or the acquisition of climate change knowledge); it will not necessarily be beneficial (not all adaptations - deliberate or accidental will generate benefits) yet it will still be adaptation

Adaptation manifest as a range of actions, and these, can in general, be grouped into two activities: building adaptive capacity; implementing adaptation action. Building adaptive capacity includes changes made to encourage adaptation, such as investigation and research, legislation, direct guidance and instruction, increasing institutional capacity to adapt, and implementing no regrets. Implementing adaptation actions are responses to actual or expected impacts of climate change. These include: managing physical hazard/change, altering exposure to that aspect of the environment, and reducing vulnerability to impact.

The inventory suggests that the definition proposed in section one, and the two-way categorisation fits with what is happening in practice. We have found a myriad of adaptation related outputs across institutions such as research projects and models, direct guidance and toolkits, legislation and policy documents, which are examples of building adaptive capacity.

From our findings we suggest that adaptive capacity is building the ability of institutions to make some kind of considered response to climate change, bearing in mind that climate change might not necessarily be the driver. Therefore, building adaptive capacity means for many institutions not exclusively to adapt to climate change, but to develop ways in which to tackle a wider host of pressures ranging from social deprivation to local environmental issues, most of which fall under the umbrella of sustainable development.

4.6 Concluding remarks

Compiling the inventory has highlighted the difficulty of deciding what actions are adaptations, and of these which are really planned as adaptations to climate change. In its broadest sense, every single action could potentially be an unplanned adaptation; each has a series of impacts and it is often very difficult to decide whether on balance it has adaptation co-benefits or not. Our selection of unplanned adaptations is essentially subjective, based on our view of what planned adaptation is.

An adaptation has been listed as planned if climate change has been considered during its planning (or more precisely, mentioned in the documentation available). However, it is noticeable that for many of the planned adaptations, climate change is only one of many stated drivers, often a minor one.

There appear to be very few, if any adaptations that are solely due to climate change. This is in clear contrast to reported mitigation actions, some of which would be unnecessary or even undesirable other than for the climate change related threats, for example, carbon sequestration and the rapid move to renewable energy.

On some occasions climate change is potentially being used to support an action that is desired for other reasons. Conversely, it is possible that climate change is the real driver, but that shorter-term benefits are being presented to obtain wider public support. Generally however, it appears that most current adaptations are justified on co-benefits and/or are 'no regret' options.

Adaptation to climate change in the UK will require a mixed set of policies and programmes in public, private and other institutions. Government needs to be aware that every action it takes could generate adaptive action that may or may not produce adaptations that are beneficial. Relying on climate change to act as a trigger for change in the private and public sector is not advisable, as institutions of all types seem to be driven by other pressures and drivers. Important drivers of climate change include: national policies on climate change. Therefore we suggest that the importance of

climate change adaptation needs to be built into many different Directives and strategies, and incorporated into existing networks and partnerships such as those initiated by UKCIP.

To conclude, emphasis should be placed on communicating the messages drawn out in this final section. What is climate change adaptation? Answer – almost every decision and action taken on anything. What affects climate change adaptation options? Answer – almost all policies, organisational structures and behavioural norms, as well as physical climate changes. Where is adaptation taking place? Answer – everywhere, throughout the UK, Europe and the rest of the world. On one hand this makes adaptation seem boundless and unmanageable by any individual, department or organisation. On the other hand this makes adaptation the responsibility of every individual in every company and every part of government. By recognising the role of every action taken in shaping adaptation outcomes, individuals should become better aware of the role they play in shaping this nations ability to adapt to climate change. Such a change in behaviour at all levels of society should make the UK better placed to prepare for the impacts of climate change over the coming years.

Acknowledgements

Our thanks go to Andy Deacon, Emily Holmes and Lisa Horrocks (Defra) who have helped to steer this project throughout its course. Also, to Chris West at the UK Climate Impacts Programme who provided invaluable input and advice in the early stages of the project. Thanks also to Alison Colls¹, Professor Andrew Watkinson¹, and Professor Tim O’Riordan² for their advice. We would like to extend our thanks particularly to those people who have made special efforts to provide us with examples of adaptation in practice, and who have helped us to develop our understanding of adaptation in practice in the UK.

¹ Tyndall Centre for Climate Change Research, School of Environmental Sciences, University of East Anglia, Norwich, NR4 7TJ

² School of Environmental Sciences, University of East Anglia, Norwich, NR4 7TJ

5. References

- Arnell, N.W. (1992) *Impacts of climate change on river flow regimes in the UK*. Journal of the Institution of Water and Environmental Management **6**: 432-442.
- Arnell, N.W. and Delaney E.K. (2004) *Adapting to Climate Change: Public Water Supply in England and Wales*. Submitted to Climatic Change.
- Arnell, N.W., 2004. Climate-change impacts on river flows in Britain: The UKCIP02 Scenarios. *Water and Environment Journal*. Vol.18, No.2.
- Arnell, N.W., and Reynard, N.S. (1996) *The effects of climate change due to global warming on river flows in Great Britain*. Journal of Hydrology **183**(3-4): 397-424.
- Association of British Insurers (2003) *The Vulnerability of UK Property to Windstorm Damage*. Association of British Insurers, London.
- Association of British Insurers (2004a) *A Changing Climate for Insurance: A Summary Report for Chief Executives and Policy Makers*. Association of British Insurers, London.
- Association of British Insurers (2004b) Evidence to EFRA Committee Report on 'Climate Change and Water Security'. Available at www.publications/parliament.uk/pa/cm200304/cmselect/cmenvfru/558/4050502.htm
- Beran, M.A. and Arnell, N.W. (1989) *Effect of Climatic Change on Quantitative Aspects of UK Water Resources*. Report to Department of the Environment. Institute of Hydrology, Wallingford.
- Berkhout, F., and J. Hertin (2004) *Learning to adapt: Organisational adaptation to climate change impacts*. Working Paper 47. Tyndall Centre for Climate Change Research, Norwich.
- Broadmeadow, M. (2002) *Climate Change: Impacts on UK forests*. Report prepared for the Forestry Commission, Edinburgh.
- Broadmeadow, M. (2000) *Climate Change – implications for forestry in Britain*. Information Note prepared for the Forestry Commission by Forest Research, UK.
- Bryant, C.R., et al., (2000) *Adaptation in Canadian agriculture to climate variability and change*. Climatic Change **45**:181-201.

- Chichton, D. (2004) *Flood Risk & Insurance in England and Wales: Are there Lessons to be learned from Scotland*. Technical Paper 1. Benfield Hazard Research Centre, London.
- Cicutti, N. (2004) *How Climate Change Affects Your Finances*. MSN Money: <http://money.msn.co.uk/MyMoney/Insight/MoneySpinner/ThisWeek/climatechange/default.asp>.
- Country and Land Business Association (2001) *Climate Change and the Rural Economy*. Country Land and Business Association.
- Constructing Excellence (2003) *Demonstrations of Sustainability; The Rethinking Construction demonstrations and how they have addressed sustainable construction issues*. The Buildings Research Establishment and Department of Trade and Industry, London.
- Cook, C. and Harrison, P.A. (2001) *Climate Change and Nature Conservation in Britain and Ireland: MONARCH - Modelling Natural Resource Responses to Climate Change*. Summary Report, UKCIP, Oxford.
- Cook, G. (2005) *Climate Change*. Scottish Parliament Information Centre (SPICe) Briefing. 21 January 2005.
- Department for the Environment, Transport and the Regions (1998) *Planning for Sustainable Development: towards better practice*. Department for the Environment, Transport and the Regions, London.
- Department for Environment, Food and Rural Affairs (2005a) *Securing the Future – UK Government sustainable development strategy*. The Stationary Office, London.
- Department for the Environment, Food and Rural Affairs (2005b) *The Impacts of Climate Change on Agriculture – a vision for our rural landscape*. Department for the Environment, Food and Rural Affairs, London.
- Department for the Environment, Food and Rural Affairs (2005c) *Agri-environment schemes help halt decline in bird populations*. Weekly Focus Index. 04 April, 2005. (<http://www.defra.gov.uk/news/issues/2005/erdp-0404.htm>)
- Department for the Environment, Food and Rural Affairs (2005d) *Environmental Stewardship - Look after your land and be rewarded*. Rural Development Service, pp.14.
- Department for the Environment, Food and Rural Affairs (2005e) '[Rural climate change forum launched](#)'. Defra News Release, 30 March 2005
- Department for the Environment, Food and Rural Affairs (2004a) [Scientific and Technical Aspects of Climate Change, including impacts and adaptation and](#)

- [associated costs](#). Global Atmospheres Division. Department for the Environment, Food and Rural Affairs, London.
- Department for the Environment, Food and Rural Affairs (2004b) *Making Space for Water: Developing a New Government Strategy for Flood and Coastal Erosion Risk Management in England: A Consultation Exercise* (PB 9792). Department for the Environment, Food and Rural Affairs, London.
- Department for the Environment, Food and Rural Affairs (2003) *The Water Act 2003*. Department for the Environment, Food and Rural Affairs, London.
- Department for the Environment, Food and Rural Affairs (2002) *Directing the Flow: Priorities for future Water Policy*. Department for the Environment, Food and Rural Affairs, London.
- Department for the Environment, Food and Rural Affairs (2001) *Flood and Defence Project Appraisal Guidance: Strategic Planning and Appraisal*. Department for the Environment, Food and Rural Affairs, London.
- Department of Trade and Industry (2004) *Sustainable Construction Brief 2*. Department of Trade and Industry, London.
- Department of Trade and Industry (2003) *Sustainable Construction Brief*. Department of Trade and Industry, London.
- Department of Trade and Industry (2000). *Building a Better Quality of Life - a strategy for more sustainable construction*. Department of Trade and Industry, London.
- Department for Transport (2004) *The Changing Climate: Its impact on the Department for Transport*. Department for Transport, London.
- Department for Environment (DoE) (2002) *Implications of Climate Change for Northern Ireland: Informing Strategy Development*, DoE Northern Ireland, Belfast.
- Dockerty, T. Lovett A., and Watkinson A. (2003) *Climate change and nature reserves: examining the potential impacts, with examples from Great Britain*. Global Environmental Change 13: 125-135.
- Doornkamp, J.C., Gregory, K.J. and Burn, A.S. (1980) *Atlas of Drought in Britain 1975-76*. Institute of British Geographers, London.
- Downing, T.E., Butterfield, R.E., Edmonds, B., Knox, J.W., Moss, S., Piper, B.S. & Weatherhead, E.K. (2003) *Climate Change and the Demand for Water*. Research Report, Stockholm Environment Institute, Oxford.

- East of England Regional Assembly (2004) *Living with Climate Change in the East of England*. In association with UKCIP. East of England Regional Assembly, Bury St. Edmunds, Suffolk.
- East Midlands Regional Assembly (2001) *Water Resources for the Future: A Strategy for the East Midlands*. East Midlands Regional Assembly, Melton Mowbray.
- English Nature (2005) *'Biodiversity Issues'*. Prepared by Duff, K. in Department for the Environment, Food and Rural Affairs (2005) *The Impacts of Climate Change on Agriculture a Vision for Our Rural Landscape*. Final Report. Department for the Environment, Food and Rural Affairs, London.
- Environment Agency (2005a) *The Climate is Changing – Time to get Ready*. The Environment Agency, London.
- Environment Agency (2005b) *Effective Flood Management: Position Statement*. www.environment-agency.gov.uk (Accessed 26/05/05)
- Environment Agency (2004) *Water Resources for the Future: Annual Review*. Environment Agency, London.
- Environment Agency (2001) *Lessons learned: Autumn 2000 Floods*. Environment Agency, London.
- Environment Agency (2001) *Water Resources for the Future: A Strategy for England and Wales*. Environment Agency, London.
- Entec, University of Dundee, and Crichton, D. (2002) *Climate Change Occurrences Review*. Scottish Executive Central Research Unit.
- ERM (2000) *Potential UK adaptation strategies for climate change*. Prepared for the Department for Environment, Transport and Rural Affairs, London.
- European Union (2000) Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for community action in the field of water policy, Official Journal of European Communities, (L327) pp.1-72.
- European Union (1992) Directive 1992/43/EEC of the European Parliament and of the Council of 21 May 1992 establishing a framework on conservation of natural habitats and wild fauna and flora. Office of the Official Publications of the EC.
- Expert Group on Climate Change and Health in the UK (2001) *Health Effects of Climate Change in the UK*. Department of Health, London.
- Forestry Commission (2005) Website accessed on 25/05/05. www.forestry.gov.uk

- Friends of the Earth (2003) *Responding to Regional Spatial Strategies What they are and how to deal with them*. Briefing paper. Additional information can be found at (http://www.foe.co.uk/resource/briefings/regional_spatial_strat.pdf) (Last Accessed 9 May, 2005).
- Garvin, S. L., Phillipson, M.C. *et al.* (1998). *Impact of climate change on building*, Building Research Establishment, London.
- Graves, H. M., and Phillipson, M.C. (2000). *Potential implications of climate change in the built environment*. Building Research Establishment (BRE)/Foundation for the Built Environment(FBE), Watford.
- Green, R.E, Harley, M., Miles, L., Scharlemann, J., Watkinson, A., Watts, O. (eds.) (2003) *Global Climate Change and Biodiversity*. University of East Anglia, Norwich, UK.
- Hammett, P. 2005. *Irrigators working in groups*, UK Irrigation 22, UKIA, Cranfield University, Bedford.
- Harrison, P.A., Berry, P.M., and Dawson, T.E., (eds.) (2001) *Climate Change and Nature Conservation in Britain and Ireland: MONARCH - Modelling Natural Resource Responses to Climate Change* Technical Report, UKCIP, Oxford.
- Hasegawa, T. (2004) *Climate change, adaptation and government policy for the building sector*. Building Research and Information **32**(1): 61-64.
- Hertin, J. and Berkhout, F. (2003) *Climate change and the UK house building sector: perceptions, impacts and adaptive capacity*. Building Research and Information **31**(3-4): 278-290.
- Highways Agency (2005) *Business Plan 2005-6*. The Highways Agency, Wetherby, West Yorkshire.
- Highways Agency (2003) *Building Better Roads - Towards Sustainable Construction*. The Highways Agency, Wetherby, West Yorkshire.
- House of Commons Environment Committee (1996) *First Report - Water Conservation and Supply*. HMSO, London
- Institute of Hydrology (1980) *Low Flow Studies*. Institute of Hydrology, Wallingford, Oxon.
- IUCN, English Nature, the Royal Society for the Protection of Birds, WCMC, and WWF (2003) *Climate Change and Nature Adapting for the Future*. Information paper prepared by IUCN, English Nature, the Royal Society for the Protection of Birds, and WCMC, and WWF. Available at <http://www.iucn.org/themes/climate/docs/climateandnature.pdf>

- Kent Environment Strategy (2005) *A Focus for the Future of Kent's Environment*. Kent County Council, pp.42.
- Kerr, A. and McLeod, A. (2001) *Potential Adaptation Strategies for Climate Change*. Scottish Executive, Scotland.
- Kerr, A., Shackley, S., Milne, R., and Allen, S. (1999) *Climate Change: Scottish Implications Scoping Study*. Scottish Executive Central Research Unit, Edinburgh.
- Knox and Weatherhead (2003) *Trickle Irrigation in England and Wales*. Environment Agency R&D Technical Report W6-070/TR.
- Land Use Consultants (2005) *Yorkshire and Humber Regional Spatial Strategy Biodiversity and Natural Environment Study*. Final Report. Prepared for Yorkshire and Humber Biodiversity Forum. Land Use Consultants, London.
- Liso, K.R., Aandahl, G. et al. (2003) *Preparing for climate change impacts in Norway's build environment*. Building Research and Information **31**(3-4): 200-209.
- Lister, D.H., and Subak, S. (1999) *Warm-weather crops: forage maize*. pp.50-51. In: Cannell, M.G.R., Palutikof, J.P., and Sparks, T.H. (eds.) *Indicators of Climate Change in the UK*. Centre for Ecology and Hydrology, UK
- London Climate Change Partnership (2002) *London's Warming: The Impacts of Climate Change on London*. The London Climate Change Partnership, London.
- Lowe, R. (2001) *A review of recent and current initiatives on climate change and its impact on the built environment: Impact, effectiveness and recommendations*. Centre for the Built Environment, Leeds.
- McKenzie Hedger, M., Gawith, M., Brown I., Connell, R. and Downing, T.E. [ed.] (2000) *Climate change: Assessing the impacts — identifying the responses. The first three years of the UK Climate Impacts Programme*. UKCIP Technical Report. UKCIP & DETR, Oxford.
- McCarthy, J. J. et al. (2001) *Climate Change 2001: Impacts, Adaptation and Vulnerability*. Contribution of Working Group II to the Third Assessment Report of the intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.
- Mills, E. (2003) *Climate change, insurance and the buildings sector: technological synergisms between adaptation and mitigation*. Building Research and Information **31**(3-4): 257-277.
- Milne, J (2002) *Better Flood Management: the insurance perspective*. Proceedings of the Institution of Civil Engineers. Municipal Engineer 151 Issue 4: 283-286.

- National Assembly for Wales (2001) *Climate Change Wales: Learning to Live Differently (The Welsh Climate Change Programme)*, NAW, Cardiff.
- National Assembly for Wales (2002) *Community Leadership and Climate Change Guidance for Chief Executives of Welsh Local Authorities*. National Assembly for Wales, Cardiff.
- National Assembly for Wales (2001) *Climate Change Wales: Learning to Live Differently (the Welsh Climate Change Programme)*. National Assembly for Wales, Cardiff
- National Assembly for Wales (2000) *Wales: Changing Climate, Challenging Choices: The Impacts of Climate Change in Wales from 2000 to 2080*. In association with UKCIP. The National Assembly of Wales, Cardiff.
- National Express Group Plc. (2004) *Corporate Social Responsibility Report*. National Express Group, Birmingham.
- Network Rail (2005) *Management Plan*. Network Rail, London.
- Network Rail (2003) *Safety and Environment Plan*. Network Rail, London.
- Norwich Union (2005) 'Norwich Unions's revolutionary flood map begins to roll out' Small Business Insurance 3 March 2005. Available at www.norwichunionselfemployed.co.uk/business_insurance/release37771.html
- Oakes, T. (2002) *Flood and coastal defence and municipal engineers*. Proceedings of the Institution of Civil Engineers. Municipal Engineer 151 Issue 4: 287-294
- Office of the Deputy Prime Minister (2004a) *Planning Policy Guidance 25: Development and flood risk*. ODPM, London.
http://www.odpm.gov.uk/stellent/groups/odpm_planning/documents/page/odpm_plan_606931.hcsp.
- Office of the Deputy Prime Minister (2004b) *Regional Planning Guidance 6: East Anglia to 2016*. Office of the Deputy Prime Minister, London.
- Office of the Deputy Prime Minister (2004c) *The Planning Response to Climate Change: Advice on better practice*. ODPM, London.
- Olesen, J.E., and Bindi, M. (2002) *Consequences of climate change for European agricultural productivity, land use and policy*. European Journal of Agronomy **16**(4): 239-262.
- Organisation for Economic Co-operation and Development (2003) *Policy Brief: Environmentally Sustainable Buildings: Challenges and Policies*. Organisation for Economic Co-operation and Development.

- Ostrom, E. (1990) *Governing the Commons. The Evolution of Institutions for Collective Action*. Series title: The Political Economy of Institutions and Decisions. Cambridge University Press, New York.
- Ofwat (2004) *Future Water and Sewerage Charges 2005-10: Final Determinations*, Ofwat, Birmingham
- Rail Safety and Standards Board (2003) *Safety implications of weather, climate and climate change*. Rail Safety and Standards Board, London.
- Roberts, L. (2005) 'A crop as high as an elephant's eye' NFU Online. Available at http://www.nfu.org.uk/stellentdev/groups/public/documents/regional_article/acrop_ashighasanel_ia412f4580-4.hcsp
- Rounsevell, M.D.A., Evans S.P., and Bullock, P. (1999) *Climate change and agricultural soils: Impacts and adaptation*. Climatic Change 43(4): 683-709.
- Rudge, V and Gowing, J. (2004) *The Development of Farmer Organised Abstraction Groups in East Anglia*, UK Irrigation 21; UKIA, Cranfield, Bedford.
- Severn Trent Water (2002) *Your Water Safe in Our Hands*. Water Efficiency Report, Severn Trent Environmental Leadership, Severn Trent.
- Scottish Executive (1997) *Flood Prevention and Land Drainage (Scotland) Act 1997* Elizabeth II. Chapter 36, the Stationery Office Limited.
- Scottish Executive (2001) *A Forward Strategy for Scottish Agriculture and Prevention of Pollution from Agricultural Activity*. Scottish Executive. Available at <http://www.scotland.gov.uk/library3/agri/agss.pdf>
- Scottish Executive (2004a) *Scottish Planning Policy 7: Planning and Flooding*. Scottish Executive Development Department. Available at <http://www.scotland.gov.uk/library5/planning/spp7.pdf>
- Scottish Executive (2004b) *Scotland's Biodiversity– its in your hands. A strategy for the conservation and enhancement of biodiversity in Scotland*. Draft Research Strategy. Scottish Biodiversity Forum, pp.21.
- Scottish Executive Environment Group (2004) *Review of the Scottish Climate Change Programme a Consultation*. Scottish Executive Available information at www.scotland.gov.uk/Consultations
- Scottish Water Sustainability Report (2002/2003). Available information at <http://www.scottishwater.co.uk/portal/page>

- Smit, B., and Skinner, M.W. (2002) *Adaptation options in agriculture to climate change: a typology*. Mitigation and Adaptation Strategies for Global Change 7(1).
- Smyth, A., Montgomery W.I., Favis-Mortlock, D., Allen, S. (eds.) (2002) *Implications of Climate Change for Northern Ireland: Informing Strategy Development*. The Scotland and Northern Ireland Forum for Environmental Research (SNIFFER).
- Sorrell, S. (2003) *Making the link: climate policy and the reform of the UK construction industry*. Energy Policy 31: 865-878.
- Stemmers, K. (2003) *Towards a research agenda for adapting to climate change*. Building Research and Information 31(3-4): 291-301.
- Sustainable Building Task Group (2004) *Better Buildings – Better Lives*. Her Majesty's Stationary Office, London.
- Sustainable Construction Task Group (2003) *The UK Construction Industry: progress towards more sustainable construction 2000-2003*. London, Sustainable Construction Task Group, London.
- Sustainable Construction Task Group (2002) *Reputation, Risk and Reward: The Business Case for Sustainability in the UK Property Sector*. The Sustainable Construction Task Group, London.
- Sustainable Development Round Table for the East of England and UK Climate Impacts Programme (2004) *Living with Climate Change in the East of England*. Sustainable Development Round Table for the East of England, now the East of England Regional Assembly, Bury St. Edmunds, Suffolk.
- Trust News, 2005. 'Essex Wildlife Trust Wins National Award fro Coastal Realignment Scheme. Available information at <http://www.essexwt.org.uk/Graham/news.htm>.
- UK Climate Impacts Programme and EPSRC (2003) *Building Knowledge for a Changing Climate: The impacts of climate change on the built environment*. The UK Climate Impacts Programme, Oxford.
- Weatherhead, E.K. and Danert, K. (2002) Survey of irrigation of outdoor crops in 2001 – England. Cranfield University, Silsoe.
- Weatherhead, K. (2004) *The Water Act 2003 - An introduction to changes in irrigation water abstraction management plans in England and Wales*. Based on an open presentation to the 2004 UK Irrigation Association Annual Conference, "The Water Bill, water trading, efficiency and beyond".
- Welsh Assembly (2001) *Climate Change Wales: Learning to live differently*. Air and Quality Environment Branch, Environmental Protection Division, NAW, Cardiff.

- Welsh Office (1998) *Transporting Wales into the Future*. Transport Policy for Wales. Her Majesty's Stationary Office, London.
- Werritty, A., Black, A., Duck, R., Finlinson, B., Thurston, N., Shackley, S., and Crichton, D. (2002) *Climate change; Flood Occurrences Review*. Environment Group Research Programme Findings No.19. Scottish Executive Research Unit, Scotland.
- White, R. R. (2004) *Managing and interpreting uncertainty for climate change risk*. Building Research and Information **32**(5): 438-448.
- Whitmarsh, L. (2005) *A study of public understanding of and response to climate change in the South of England*. Unpublished doctoral thesis. Department of Psychology, University of Bath, Bath, UK.
- Wilson, M. I. and Burtwell, M.H. (2002) *Prioritising future construction research and adapting to climate change: infrastructure (transport and utilities)*. TRL Ltd. for the Construction Research and Innovation Strategy Panel, Wokingham.
- Yorkshire Forward (2002) *Warming up the region – Yorkshire and Humber Climate Impacts Scoping Study*. Yorkshire Forward, Leeds, 30pp.
- Yorkshire Forward (2004) *Climate Adaptation Toolkit*. Yorkshire Forward, Leeds.
- Yorkshire Forward (2002) *Warming up the region - Yorkshire and Humber Climate Change Impact Scoping Study*. Prepared in association with UKCIP. Yorkshire Forward, Leeds.
- Yorkshire and Humber Assembly (2004) *Shaping the Future: Developing a Regional Spatial Strategy for Yorkshire and the Humber Project Plan*. Yorkshire and Humber Assembly.

6. Annex

Annex 1: Evolution of water supply sector in the UK

Water conservation and supply was put on the National agenda following the drought of 1976 and hot summer of 1995. The 1975/76 drought, which was considered an 'extreme and rare event' resulted in responses from the water supply industry (public) to improve interconnections between supply sources, provide some investment to new sources, and to develop improved drought management procedures (House of Commons Environment Committee, 1996). Scientists searched for similar patterns of past droughts (Doornkamp et al., 1980) and new methods were developed to estimate frequency of drought flows (Institute of Hydrology, 1980). These new design methods produced assumed a stable global climate. In 1989, the first review of the potential implications of climate change for water supply was commissioned by Department for Environment (Beran and Arnell, 1989) and the first peer reviewed papers published in early 1990s (Arnell, 1992).

In 1989 public water supplies in England and Wales also fell under private-sector long-term license agreements. Public water supplies are provided by 10 private water-shed based companies which both supply water and treat effluent (water and sewage companies) while "water only companies" include 15 companies geographically nested within larger companies just supply water (Arnell and Delaney, 2004). The 1990s also saw a small series of droughts, while this time response came under responsibility of privatised water supply companies. In 1996 the Department of Environment (DoE) commissioned a government review of water supply, which highlighted climate change and recommended more strategic planning to water resources planning. The water sector is treated slightly differently in the Devolved Administrations where water companies remain regulated such as Scottish Water.

Annex 2: Recent history of flooding in the UK and policy responses

Climate change is likely to have devastating impacts on flooding in inland and coastal areas in the UK. We are already seeing that large parts of the UK are vulnerable to the devastating impacts of flooding. Approximately 10 000 Km² or 8% of the total area of England's land surface is at risk from river flooding, including tidal rivers and estuaries (Oakes, 2002). The severe flooding events in inland and coastal areas in recent years have had serious impacts across many parts of the UK. These events have involved many agencies and caused disruption to thousands of households and businesses (Milne, 2002). For example, the Easter floods of 1998 resulted in five deaths, £400 million damage and evacuation of 1500 people from their homes (Oakes, 2002). Following the floods of 2000 in the UK, reportedly the wettest weather in 270 years, around 700 hundred locations around England and Wales experienced flooding with damage to more than 10,000 homes (Milne, 2002), and the Environment Agency together with local authorities and the army saved approximately 37 000 other homes (Environment Agency, 2001). The Association of British Insurers had to deal with more than 30 000 claims, paying out excess of £1 billion for flooding and associated storm damages (Association of British Insurers, 2003; 2004).

In response, public institutions across the UK have strived to respond with policy, planning and guidance. For example, Defra published in 2004 a consultation paper entitled 'Making Space for Water: Developing a New Government Strategy for Flood and Coastal Erosion Risk Management in England: A Consultation Exercise'. This paper outlines ideas for dealing with all types of flooding - coastal, river, groundwater, sewers and urban and road drainage problems, noting that in the floods of 2000 about 40% of the houses were not flooded by the river or sea but by drains or ground water. It stipulates that Government funding of the flood defence programme in England and Wales currently stands at a record £478 m and is set to rise to £564 million for 2005-2008. Defra has also developed Flood and Coastal Defence Project Appraisal Guidance (Defra, 2001), which makes specific recommendations about incorporating climate change into assessment and design.

The management of flood and coastal defence in England and Wales is shared between the Environment Agency, which is the single largest flood defence authority in England and Wales, over 400 local authorities and the 228 Internal Drainage Boards (IDBs) (Environment Agency, 2005b). This arrangement is noted to be complex and not always understood by those affected by flooding, and flood and coastal services are often provided to meet other economic, environmental and social objectives (Oakes, 2002). Chichton (2004) outlines a long list of problems associated with inland and coastal flooding in England and Wales, of which one is climate change. He notes that in contrast to England and Wales, Scotland has developed sophisticated measures with regard to planning and coordination, which are proving to be effective in preventing increases in exposure to flood hazards. In particular, he attributes Scotland's success to the network of Flood Liaison and Advice Groups, in which stakeholders have an opportunity to affect and influence local policies and advise local planners (Chichton, 2004).

Annex 3: Brief summary of academic literature on climate change adaptation in the planning and construction sectors

The planning and construction industry concerns diverse stakeholders in public, private and other institutions. As Hasegawa (2004) states, these range from planning bodies (e.g. the Office of the Deputy Prime Minister and regional planning authorities), to institutions concerned with insurance, design and development (e.g. private major construction companies), and small scale architecture firms and builders.

There is some evidence in the published literature that climate change adaptation is starting to happen in the planning and construction sector but that change is at a very early stage, and that little consideration appears to have been given to climate change adaptation thus far (see, for example, Berkhout and Hertin, 2004; Hertin and Berkhout, 2003; Liso et al., 2003; Steemers, 2003a). Many of these suggestions in the academic literature are reflected by the findings of this study.

Annex 4: Potential impacts of climate change on biodiversity in the UK

Limited attention has been paid to the changes that are likely to occur to the World's biodiversity over the next few decades attributed to climate change. Yet climate change, coupled with fragmentation of landscape threatens many of the world's ecosystems (IUCN et al, 2003). Under the UKCIP Scenarios biodiversity will be severely impacted in the UK. Evidence already suggests that species such as the Red Admiral butterfly emerges 40 days earlier and flies 40 days longer than in the past. Plants are flowering earlier, notably the Winter aconite flowers one month earlier in Norfolk and the Snowdrop is out in November in the South of England (English Nature, 2005).

Green et al. (2003) suggest that there is patchy awareness on biodiversity and the impacts of climate change, but that the UK has the best data. They point out that traditionally the UK conservation approach has been highly interventionist as a result of its land use history and that allowing for natural processes to take their course in a small number of sites could be considered to increase understanding of appropriate biodiversity responses to climate change. Barriers to address climate change and biodiversity do exist. Green et al., 2003 identify these barriers as: difficulties of convincing people of the real threats of climate change; dissuading them that it could even be a good thing; and getting rid of inertia among people, where if species are 'doomed' why should people bother to take action. Among many conservation biologists there is also limited awareness of the impacts of climate change.

Annex 5: Potential impacts of climate change on the agricultural and forestry sectors

UK agriculture faces the challenge of climate change in coming decades. The impacts of higher mean temperature, increased precipitation and storms and sea level rise all have serious implications for UK's agricultural sector (Defra, 2005b). It is widely anticipated that the range of arable crops currently grown will move northwards (hectareage of forage maize has already been highlighted as an indicator of climate change) and the area grown has risen from approximately 20,000 hectares in 1985 to over 100, 000 in 1995 and only partly due to improved plant varieties (Lister and Subak, 2000). Types of adaptation in the farming sector include switching to alternative crops, shifting crops from areas that are vulnerable to drought, or investing in equipment that helps to reduce the severity of the impacts of climate change.

It is anticipated that agricultural business will need to adapt to the effect of climate change to ensure economic viability and to agriculture's impact on the environment. For example, the costs of the 1995 summer drought to the agriculture industry have been estimated at a loss of £457 million due to reduced income and increasing costs in equipment. Evidence suggests that those farmers who implemented adaptation and management changes at that time secured advantages over others (Defra, 2005).

The challenges faced by farmers is to separate adaptation to climate variability from adaptation to a long-term climate change. In developed countries the adaptive capacity of agriculture is generally high, with the ability of individual farmers to respond over short time scales (5 years or less) to climate variability as well as other drivers such as market and environmental expectations while greater vulnerability and constraints to adaptation existing in forestry systems and over larger catchments areas (i.e. beyond individual farmers)¹⁷ Actions will be required to address the substantial impacts of climate change on the land use sector.

¹⁷ This was highlighted in the International workshop on adaptation practices and strategies in developed countries, 11-13 October 2004, Wellington New Zealand

Many of the problems facing the UK agriculture are beyond the scope of this study. In fact, there are few examples of planned adaptation in practice at the moment, which might be attributed to the problems that CAP subsidies have caused to unsustainable land use practices. The review of the Common Agricultural Policy and the Government's policies for rural regeneration could however be beneficial to many of the anticipated impacts of climate change on the agricultural sector.

Annex 6: Potential impacts of climate change on the transport sector

The transport sector is likely to be affected by the impacts of climate change in a number of ways. The Department for Transport (2004) notes that the following issues are most critical to the transport industry:

- Increased flooding during winter, affecting all modes of transport. The risks being greatest in flood plains and where urban drains are overloaded.
- Some coastal stretches may be at risk of inundation by the sea during periods of particularly high winds when coupled with the highest tides. This will be of particular concern for coastal railways, e.g. in Wales and parts of South West England.
- More extreme heat during summer could lead to heat exhaustion for vulnerable passengers on the London Underground, particularly when subject to delays.
- Sudden structural failures are extremely uncommon, but, if not action were taken, the risk of such failures could increase due to soil saturation and the scouring action of rain/high rivers.
- Difficult driving conditions due to snow and ice would decrease but the number of days when driving was difficult due to rain, leaves and storms would increase.
- Even though the number of days of frost and snow will decrease, it will be important to retain experience in dealing with sub-zero temperatures.

The Department for Transport emphasises that to respond to these changes, infrastructure will need to be built and maintained to withstand hotter temperatures, worse storms, more intense rain, and higher sea levels. Contingency plans will also have to change in expectation that they will be needed more often and for more extreme impacts. A number of organisations, particularly in the public sector and concerning roads and the rail network, already have programmes underway which address this need to adapt – some of these will be given as examples in the following section of this report.

The Tyndall Centre working paper series presents results from research which are mature enough to be submitted to a refereed journal, to a sponsor, to a major conference or to the editor of a book. The intention is to enhance the early public availability of research undertaken by the Tyndall family of researchers, students and visitors. They can be downloaded from the Tyndall Website at:

http://www.tyndall.ac.uk/publications/working_papers/working_papers.shtml

The accuracy of working papers and the conclusions reached are the responsibility of the author(s) alone and not the Tyndall Centre.

Papers available in this series are:

- Haxeltine A., Seyfang G., (2009) **Transitions for the People: Theory and Practice of 'Transition' and 'Resilience' in the UK's Transition Movement:** Tyndall Working Paper 134;
- Tomei J., Upham P., (2009) **Argentinean soy based biodiesel: an introduction to production and impacts:** Tyndall Working Paper 133;
- Whitmarsh L, O'Neill S, Seyfang G., Lorenzoni I., (2008) **Carbon Capability: what does it mean, how prevalent is it, and how can we promote it?:** Tyndall Working Paper 132;
- Huang Y., Barker T., (2009) **Does Geography Matter for the Clean Development Mechanism? :** Tyndall Working Paper 131;
- Huang Y., Barker T., (2009) **The Clean Development Mechanism and Sustainable Development: A Panel Data Analysis:** Tyndall Working Paper 130;
- Dawson R., Hall J, Barr S, Batty M., Bristow A, Carney S, Dagoumas, A., Evans S., Ford A, Harwatt H., Kohler J., Tight M, (2009) **A blueprint for the integrated assessment of climate change in cities:** Tyndall Working Paper 129;
- Carney S, Whitmarsh L, Nicholson-Cole S, Shackley S., (2009) **A Dynamic Typology of Stakeholder Engagement within Climate Change Research:** Tyndall Working paper 128;
- Goulden M, Conway D, Persechino A., (2008) **Adaptation to climate change in international river basins in Africa: a review:** Tyndall Working paper 127;
- Bows A., Anderson K., (2008) **A bottom-up analysis of including aviation within the EU's Emissions Trading Scheme:** Tyndall Working Paper 126;
- Al-Saleh Y., Upham P., Malik K., (2008) **Renewable Energy Scenarios for the Kingdom of Saudi Arabia:** Tyndall Working Paper 125
- Scricciu S., Barker T., Smith V., (2008) **World economic dynamics and technological change: projecting interactions between economic output and CO2 emissions :** Tyndall Working Paper 124
- Bulkeley H, Schroeder H., (2008)

Governing Climate Change Post-2012: The Role of Global Cities - London:

Tyndall Working Paper 123

- Schroeder H., Bulkeley H, (2008)

Governing Climate Change Post-2012: The Role of Global Cities, Case-Study: Los Angeles:

Tyndall Working Paper 122

- Wang T., Watson J, (2008) **Carbon Emissions Scenarios for China to 2100:** Tyndall Working Paper 121

- Bergman, N., Whitmarsh L, Kohler J., (2008) **Transition to sustainable development in the UK housing sector: from case study to model implementation:** Tyndall Working Paper 120

- Conway D, Persechino A., Ardoin-Bardin S., Hamandawana H., Dickson M, Dieulin C, Mahe G, (2008) **RAINFALL AND WATER RESOURCES VARIABILITY IN SUB-SAHARAN AFRICA DURING THE 20TH CENTURY:** Tyndall Centre Working Paper 119

- Starkey R., (2008) **Allocating emissions rights: Are equal shares, fair shares? :** Tyndall Working Paper 118

- Barker T., (2008) **The Economics of Avoiding Dangerous Climate Change:** Tyndall Centre Working Paper 117

- Estrada M, Corbera E., Brown K, (2008) **How do regulated and voluntary carbon-offset schemes compare?:** Tyndall Centre Working Paper 116

- Estrada Porrua M, Corbera E., Brown K, (2007) **REDUCING GREENHOUSE GAS EMISSIONS FROM DEFORESTATION IN DEVELOPING COUNTRIES: REVISITING THE ASSUMPTIONS:** Tyndall Centre Working Paper 115

- Boyd E., Hultman N E., Roberts T., Corbera E., Ebeling J., Liverman D, Brown K, Tippmann R., Cole J., Mann P, Kaiser M., Robbins M, (2007) **The Clean**

Development Mechanism: An assessment of current practice and future approaches for policy: Tyndall Centre Working Paper 114

- Hanson, S., Nicholls, R., Balson, P., Brown, I., French, J.R., Spencer, T., Sutherland, W.J. (2007) **Capturing coastal morphological change within regional integrated assessment: an outcome-driven fuzzy logic approach:** Tyndall Working Paper No. 113

- Okereke, C., Bulkeley, H. (2007) **Conceptualizing climate change governance beyond the international regime: A review of four theoretical approaches:** Tyndall Working Paper No. 112

- Doulton, H., Brown, K. (2007) **'Ten years to prevent catastrophe'? Discourses of climate change and international development in the UK press:** Tyndall Working Paper No. 111

- Dawson, R.J., et al (2007) **Integrated analysis of risks of coastal flooding and cliff erosion under scenarios of long term change:** Tyndall Working Paper No. 110

- Okereke, C., (2007) **A review of UK FTSE 100 climate strategy and a framework for more in-depth analysis in the context of a post-2012 climate regime:** Tyndall Centre Working Paper 109

- Gardiner S., Hanson S., Nicholls R., Zhang Z., Jude S., Jones A.P., et al (2007) **The Habitats Directive, Coastal Habitats and Climate Change – Case Studies from the South Coast of the UK:** Tyndall Centre Working Paper 108

- Schipper E. Lisa, (2007) **Climate Change Adaptation and Development: Exploring the Linkages:** Tyndall Centre Working Paper 107

- Okereke C., Mann P, Osbahr H, (2007) **Assessment of key negotiating issues at Nairobi climate COP/MOP and what it means for the future of the climate regime:** Tyndall Centre Working Paper No. 106
- Walkden M, Dickson M, (2006) **The response of soft rock shore profiles to increased sea-level rise.** : Tyndall Centre Working Paper 105
- Dawson R., Hall J, Barr S, Batty M., Bristow A, Carney S, Evans E.P., Kohler J., Tight M, Walsh C, Ford A, (2007) **A blueprint for the integrated assessment of climate change in cities.** : Tyndall Centre Working Paper 104
- Dickson M., Walkden M., Hall J., (2007) **Modelling the impacts of climate change on an eroding coast over the 21st Century:** Tyndall Centre Working Paper 103
- Klein R.J.T, Erickson S.E.H, Næss L.O, Hammill A., Tanner T.M., Robledo, C., O'Brien K.L.,(2007) **Portfolio screening to support the mainstreaming of adaptation to climatic change into development assistance:** Tyndall Centre Working Paper 102
- Agnolucci P., (2007) **Is it going to happen? Regulatory Change and Renewable Electricity:** Tyndall Centre Working Paper 101
- Kirk K., (2007) **Potential for storage of carbon dioxide in the rocks beneath the East Irish Sea:** Tyndall Centre Working Paper 100
- Arnell N.W., (2006) **Global impacts of abrupt climate change: an initial assessment:** Tyndall Centre Working Paper 99
- Lowe T.,(2006) **Is this climate porn? How does climate change communication affect our perceptions and behaviour?,** Tyndall Centre Working Paper 98
- Walkden M, Stansby P,(2006) **The effect of dredging off Great Yarmouth on the wave conditions and erosion of the North Norfolk coast.** Tyndall Centre Working Paper 97
- Anthoff, D., Nicholls R., Tol R S J, Vafeidis, A., (2006) **Global and regional exposure to large rises in sea-level: a sensitivity analysis.** This work was prepared for the Stern Review on the Economics of Climate Change: Tyndall Centre Working Paper 96
- Few R., Brown K, Tompkins E. L, (2006) **Public participation and climate change adaptation,** Tyndall Centre Working Paper 95
- Corbera E., Kosoy N, Martinez Tuna M, (2006) **Marketing ecosystem services through protected areas and rural communities in Meso-America: Implications for economic efficiency, equity and political legitimacy,** Tyndall Centre Working Paper 94
- Schipper E. Lisa, (2006) **Climate Risk, Perceptions and Development in El Salvador,** Tyndall Centre Working Paper 93
- Tompkins E. L, Amundsen H, (2005) **Perceptions of the effectiveness of the United Nations Framework Convention on Climate Change in prompting behavioural change,** Tyndall Centre Working Paper 92
- Warren R., Hope C, Mastrandrea M, Tol R S J, Adger W. N., Lorenzoni I., (2006) **Spotlighting the impacts functions in integrated assessments. Research Report Prepared for the Stern Review on the Economics of Climate Change,** Tyndall Centre Working Paper 91

- Warren R., Arnell A, Nicholls R., Levy P E, Price J, (2006) **Understanding the regional impacts of climate change: Research Report Prepared for the Stern Review on the Economics of Climate Change**, Tyndall Centre Working Paper 90
- Barker T., Qureshi M, Kohler J., (2006) **The Costs of Greenhouse Gas Mitigation with Induced Technological Change: A Meta-Analysis of Estimates in the Literature**, Tyndall Centre Working Paper 89
- Kuang C, Stansby P, (2006) **Sandbanks for coastal protection: implications of sea-level rise. Part 3: wave modelling**, Tyndall Centre Working Paper 88
- Kuang C, Stansby P, (2006) **Sandbanks for coastal protection: implications of sea-level rise. Part 2: current and morphological modelling**, Tyndall Centre Working Paper 87
- Stansby P, Kuang C, Laurence D, Launder B, (2006) **Sandbanks for coastal protection: implications of sea-level rise. Part 1: application to East Anglia**, Tyndall Centre Working Paper 86
- Bentham M, (2006) **An assessment of carbon sequestration potential in the UK – Southern North Sea case study**: Tyndall Centre Working Paper 85
- Anderson K., Bows A., Upham P., (2006) **Growth scenarios for EU & UK aviation: contradictions with climate policy**, Tyndall Centre Working Paper 84
- Williamson M., Lenton T., Shepherd J., Edwards N, (2006) **An efficient numerical terrestrial scheme (ENTS) for fast earth system modelling**, Tyndall Centre Working Paper 83
- Bows, A., and Anderson, K. (2005) **An analysis of a post-Kyoto climate policy model**, Tyndall Centre Working Paper 82
- Sorrell, S., (2005) **The economics of energy service contracts**, Tyndall Centre Working Paper 81
- Wittneben, B., Haxeltine, A., Kjellen, B., Köhler, J., Turnpenny, J., and Warren, R., (2005) **A framework for assessing the political economy of post-2012 global climate regime**, Tyndall Centre Working Paper 80
- Ingham, I., Ma, J., and Ulph, A. M. (2005) **Can adaptation and mitigation be complements?**, Tyndall Centre Working Paper 79
- Agnolucci, P (2005) **Opportunism and competition in the non-fossil fuel obligation market**, Tyndall Centre Working Paper 78
- Barker, T., Pan, H., Köhler, J., Warren., R and Winne, S. (2005) **Avoiding dangerous climate change by inducing technological progress: scenarios using a large-scale econometric model**, Tyndall Centre Working Paper 77
- Agnolucci, P (2005) **The role of political uncertainty in the Danish renewable energy market**, Tyndall Centre Working Paper 76
- Fu, G., Hall, J. W. and Lawry, J. (2005) **Beyond probability: new methods for representing uncertainty in projections of future climate**, Tyndall Centre Working Paper 75
- Ingham, I., Ma, J., and Ulph, A. M. (2005) **How do the costs of adaptation affect optimal mitigation when there is uncertainty, irreversibility and learning?**, Tyndall Centre Working Paper 74

- Walkden, M. (2005) **Coastal process simulator scoping study**, Tyndall Centre Working Paper 73
- Lowe, T., Brown, K., Suraje Dessai, S., Doria, M., Haynes, K. and Vincent., K (2005) **Does tomorrow ever come? Disaster narrative and public perceptions of climate change**, Tyndall Centre Working Paper 72
- Boyd, E. Gutierrez, M. and Chang, M. (2005) **Adapting small-scale CDM sinks projects to low-income communities**, Tyndall Centre Working Paper 71
- Abu-Sharkh, S., Li, R., Markvart, T., Ross, N., Wilson, P., Yao, R., Steemers, K., Kohler, J. and Arnold, R. (2005) **Can Migrogrids Make a Major Contribution to UK Energy Supply?**, Tyndall Centre Working Paper 70
- Tompkins, E. L. and Hurlston, L. A. (2005) **Natural hazards and climate change: what knowledge is transferable?**, Tyndall Centre Working Paper 69
- Bleda, M. and Shackley, S. (2005) **The formation of belief in climate change in business organisations: a dynamic simulation model**, Tyndall Centre Working Paper 68
- Turnpenny, J., Haxeltine, A. and O’Riordan, T., (2005) **Developing regional and local scenarios for climate change mitigation and adaptation: Part 2: Scenario creation**, Tyndall Centre Working Paper 67
- Turnpenny, J., Haxeltine, A., Lorenzoni, I., O’Riordan, T., and Jones, M., (2005) **Mapping actors involved in climate change policy networks in the UK**, Tyndall Centre Working Paper 66
- Adger, W. N., Brown, K. and Tompkins, E. L. (2004) **Why do resource managers make links to stakeholders at other scales?**, Tyndall Centre Working Paper 65
- Peters, M.D. and Powell, J.C. (2004) **Fuel Cells for a Sustainable Future II**, Tyndall Centre Working Paper 64
- Few, R., Ahern, M., Matthies, F. and Kovats, S. (2004) **Floods, health and climate change: a strategic review**, Tyndall Centre Working Paper 63
- Barker, T. (2004) **Economic theory and the transition to sustainability: a comparison of approaches**, Tyndall Centre Working Paper 62
- Brooks, N. (2004) **Drought in the African Sahel: long term perspectives and future prospects**, Tyndall Centre Working Paper 61
- Few, R., Brown, K. and Tompkins, E.L. (2004) **Scaling adaptation: climate change response and coastal management in the UK**, Tyndall Centre Working Paper 60
- Anderson, D and Winne, S. (2004) **Modelling Innovation and Threshold Effects In Climate Change Mitigation**, Tyndall Centre Working Paper 59
- Bray, D and Shackley, S. (2004) **The Social Simulation of The Public Perceptions of Weather Events and their Effect upon the Development of Belief in Anthropogenic Climate Change**, Tyndall Centre Working Paper 58
- Shackley, S., Reiche, A. and Mander, S (2004) **The Public Perceptions of Underground Coal Gasification (UCG): A Pilot Study**, Tyndall Centre Working Paper 57

technological development, Tyndall Centre Working Paper 48

- Vincent, K. (2004) **Creating an index of social vulnerability to climate change for Africa**, Tyndall Centre Working Paper 56
- Mitchell, T.D. Carter, T.R., Jones, J.P.D, Hulme, M. and New, M. (2004) **A comprehensive set of high-resolution grids of monthly climate for Europe and the globe: the observed record (1901-2000) and 16 scenarios (2001-2100)**, Tyndall Centre Working Paper 55
- Turnpenny, J., Carney, S., Haxeltine, A., and O'Riordan, T. (2004) **Developing regional and local scenarios for climate change mitigation and adaptation Part 1: A framing of the East of England** Tyndall Centre Working Paper 54
- Agnolucci, P. and Ekins, P. (2004) **The Announcement Effect And Environmental Taxation** Tyndall Centre Working Paper 53
- Agnolucci, P. (2004) **Ex Post Evaluations of CO₂ -Based Taxes: A Survey** Tyndall Centre Working Paper 52
- Agnolucci, P., Barker, T. and Ekins, P. (2004) **Hysteresis and Energy Demand: the Announcement Effects and the effects of the UK Climate Change Levy** Tyndall Centre Working Paper 51
- Powell, J.C., Peters, M.D., Ruddell, A. and Halliday, J. (2004) **Fuel Cells for a Sustainable Future?** Tyndall Centre Working Paper 50
- Awerbuch, S. (2004) **Restructuring our electricity networks to promote decarbonisation**, Tyndall Centre Working Paper 49
- Pan, H. (2004) **The evolution of economic structure under**
- Berkhout, F., Hertin, J. and Gann, D. M., (2004) **Learning to adapt: Organisational adaptation to climate change impacts**, Tyndall Centre Working Paper 47
- Watson, J., Tetteh, A., Dutton, G., Bristow, A., Kelly, C., Page, M. and Pridmore, A., (2004) **UK Hydrogen Futures to 2050**, Tyndall Centre Working Paper 46
- Purdy, R and Macrory, R. (2004) **Geological carbon sequestration: critical legal issues**, Tyndall Centre Working Paper 45
- Shackley, S., McLachlan, C. and Gough, C. (2004) **The Public Perceptions of Carbon Capture and Storage**, Tyndall Centre Working Paper 44
- Anderson, D. and Winne, S. (2003) **Innovation and Threshold Effects in Technology Responses to Climate Change**, Tyndall Centre Working Paper 43
- Kim, J. (2003) **Sustainable Development and the CDM: A South African Case Study**, Tyndall Centre Working Paper 42
- Watson, J. (2003), **UK Electricity Scenarios for 2050**, Tyndall Centre Working Paper 41
- Klein, R.J.T., Lisa Schipper, E. and Dessai, S. (2003), **Integrating mitigation and adaptation into climate and development policy: three research questions**, Tyndall Centre Working Paper 40
- Tompkins, E. and Adger, W.N. (2003). **Defining response capacity to enhance climate change policy**, Tyndall Centre Working Paper 39

- Brooks, N. (2003). **Vulnerability, risk and adaptation: a conceptual framework**, Tyndall Centre Working Paper 38
- Ingham, A. and Ulph, A. (2003) **Uncertainty, Irreversibility, Precaution and the Social Cost of Carbon**, Tyndall Centre Working Paper 37
- Kröger, K. Fergusson, M. and Skinner, I. (2003). **Critical Issues in Decarbonising Transport: The Role of Technologies**, Tyndall Centre Working Paper 36
- Tompkins E. L and Hurlston, L. (2003). **Report to the Cayman Islands' Government. Adaptation lessons learned from responding to tropical cyclones by the Cayman Islands' Government, 1988 – 2002**, Tyndall Centre Working Paper 35
- Dessai, S., Hulme, M (2003). **Does climate policy need probabilities?**, Tyndall Centre Working Paper 34
- Pridmore, A., Bristow, A.L., May, A. D. and Tight, M.R. (2003). **Climate Change, Impacts, Future Scenarios and the Role of Transport**, Tyndall Centre Working Paper 33
- Xueguang Wu, Jenkins, N. and Strbac, G. (2003). **Integrating Renewables and CHP into the UK Electricity System: Investigation of the impact of network faults on the stability of large offshore wind farms**, Tyndall Centre Working Paper 32
- Turnpenny, J., Haxeltine A. and O'Riordan, T. (2003). **A scoping study of UK user needs for managing climate futures. Part 1 of the pilot-phase interactive integrated assessment process (Aurion Project)**, Tyndall Centre Working Paper 31
- Hulme, M. (2003). **Abrupt climate change: can society cope?**, Tyndall Centre Working Paper 30
- Brown, K. and Corbera, E. (2003). **A Multi-Criteria Assessment Framework for Carbon-Mitigation Projects: Putting "development" in the centre of decision-making**, Tyndall Centre Working Paper 29
- Dessai, S., Adger, W.N., Hulme, M., Köhler, J.H., Turnpenny, J. and Warren, R. (2003). **Defining and experiencing dangerous climate change**, Tyndall Centre Working Paper 28
- Tompkins, E.L. and Adger, W.N. (2003). **Building resilience to climate change through adaptive management of natural resources**, Tyndall Centre Working Paper 27
- Brooks, N. and Adger W.N. (2003). **Country level risk measures of climate-related natural disasters and implications for adaptation to climate change**, Tyndall Centre Working Paper 26
- Xueguang Wu, Mutale, J., Jenkins, N. and Strbac, G. (2003). **An investigation of Network Splitting for Fault Level Reduction**, Tyndall Centre Working Paper 25
- Xueguang Wu, Jenkins, N. and Strbac, G. (2002). **Impact of Integrating Renewables and CHP into the UK Transmission Network**, Tyndall Centre Working Paper 24
- Paavola, J. and Adger, W.N. (2002). **Justice and adaptation to climate change**, Tyndall Centre Working Paper 23
- Watson, W.J., Hertin, J., Randall, T., Gough, C. (2002). **Renewable Energy and Combined Heat and Power Resources in the UK**, Tyndall Centre Working Paper 22

Saving or sinking the Kyoto Protocol?, Tyndall Centre Working Paper 12

• Barker, T. (2001). **Representing the Integrated Assessment of Climate Change, Adaptation and Mitigation**, Tyndall Centre Working Paper 11

• Gough, C., Taylor, I. and Shackley, S. (2001). **Burying Carbon under the Sea: An Initial Exploration of Public Opinions**, Tyndall Centre Working Paper 10

• Barnett, J. and Adger, W. N. (2001). **Climate Dangers and Atoll Countries**, Tyndall Centre Working Paper 9

• Adger, W. N. (2001). **Social Capital and Climate Change**, Tyndall Centre Working Paper 8

• Barnett, J. (2001). **Security and Climate Change**, Tyndall Centre Working Paper 7

• Goodess, C.M., Hulme, M. and Osborn, T. (2001). **The identification and evaluation of suitable scenario development methods for the estimation of future probabilities of extreme weather events**, Tyndall Centre Working Paper 6

• Barnett, J. (2001). **The issue of 'Adverse Effects and the Impacts of Response Measures' in the UNFCCC**, Tyndall Centre Working Paper 5

• Barker, T. and Ekins, P. (2001). **How High are the Costs of Kyoto for the US Economy?**, Tyndall Centre Working Paper 4

• Berkhout, F, Hertin, J. and Jordan, A. J. (2001). **Socio-economic futures in climate change impact assessment: using scenarios as 'learning machines'**, Tyndall Centre Working Paper 3

• Watson, W. J. (2002). **Renewables and CHP Deployment in the UK to 2020**, Tyndall Centre Working Paper 21

• Turnpenny, J. (2002). **Reviewing organisational use of scenarios: Case study - evaluating UK energy policy options**, Tyndall Centre Working Paper 20

• Pridmore, A. and Bristow, A., (2002). **The role of hydrogen in powering road transport**, Tyndall Centre Working Paper 19

• Watson, J. (2002). **The development of large technical systems: implications for hydrogen**, Tyndall Centre Working Paper 18

• Dutton, G., (2002). **Hydrogen Energy Technology**, Tyndall Centre Working Paper 17

• Adger, W.N., Huq, S., Brown, K., Conway, D. and Hulme, M. (2002). **Adaptation to climate change: Setting the Agenda for Development Policy and Research**, Tyndall Centre Working Paper 16

• Köhler, J.H., (2002). **Long run technical change in an energy-environment-economy (E3) model for an IA system: A model of Kondratiev waves**, Tyndall Centre Working Paper 15

• Shackley, S. and Gough, C., (2002). **The Use of Integrated Assessment: An Institutional Analysis Perspective**, Tyndall Centre Working Paper 14

• Dewick, P., Green K., Miozzo, M., (2002). **Technological Change, Industry Structure and the Environment**, Tyndall Centre Working Paper 13

• Dessai, S., (2001). **The climate regime from The Hague to Marrakech:**

- Hulme, M. (2001). **Integrated Assessment Models**, Tyndall Centre Working Paper 2
- Mitchell, T. and Hulme, M. (2000). **A Country-by-Country Analysis of Past and Future Warming Rates**, Tyndall Centre Working Paper 1

© Copyright 2009

Tyndall°Centre
for Climate Change Research

For further information please
contact

[Javier Delgado-Esteban](#)