



Business and Climate Change:
Measuring and Enhancing Adaptive Capacity

The ADAPT project

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This is the final report from Tyndall research project IT1.23 (How can business adapt to climate change?). The following researchers worked on this project:

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Final Report

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Overview of project work and outcomes

Non-technical summary

Most scientists believe that past and current greenhouse gas emissions make some climate change unavoidable. Much adaptation to these changes will be carried out by organisations, including businesses, households and government agencies. Understanding how organisations may adapt to a changing climate, and developing tools to help them through adaptation processes, is therefore vital. The ADAPT project explored how businesses can adapt their practices, policies and technologies to protect themselves from the risks caused by climate impacts, as well as make the most of new opportunities that may arise. The project has developed an organisational model of adaptation, which sees adaptation as a process of learning.

The project worked intensively with nine companies in the house-building and water services sectors over a two-year period. Through a series of interviews and workshops the project developed a picture of companies' vulnerability, their knowledge of climate-related risks and their attitudes to these risks, the adaptation measures available to the companies, and their capacity to carry out alternative adaptation strategies. The key findings of this work were that:

- awareness of climate change impacts varies markedly (generally high in the water and generally low in the house building sector);
- rather than posing entirely new problems, climate change will often add to existing pressures on companies;
- indirect impacts (e.g. rising insurance premiums or tighter regulation) will generally be more significant stimuli to adaptation than direct climatic impacts;
- organisations have available to them a potentially wide set of opportunities to adapt, but their ability to implement them is severely constrained by a range of factors, including the weakness of climate signals, the ambiguity of the link between adaptation and business advantage, and obstacles to receiving feedback about the benefits of adaptation;
- adaptation measures are often complex, involving multiple adjustments;
- in the absence of feedback about benefits, the attitudes to risk held by the company will determine which adaptation measures are adopted.
- the adaptive capacity of companies depends not only on internal characteristics, but also on external relationships. Effective adaptation will often involve cooperation with regulators, suppliers, competitors and customers.

The main outputs of the project are: a learning-based model of adaptation; an approach for assessing the adaptive capacity of organisations; and (developed in association with a complementary project) a decision-making tool to help businesses make sense of and respond to a changing climate.

Objectives

The main objectives of the project were:

1. To develop methods for assessing the adaptive capacity of business organisations
2. To characterise the internal resources and broader context for adaptive capacity for companies in two climate-sensitive sectors of UK industry (water services and house building)
3. To produce practical frameworks and tools for enhancing the capacity of firms to adapt to climatic change

The project had both theoretical and practical objectives. First, it sought to place organisations (and theories about organisational change and learning) at the centre of an analysis of climate adaptation. Second, it aimed to build on detailed interaction with a small number of companies, to develop some simple-to-apply decision-support tools for businesses.

Work undertaken

The research applied three methods: documentary research; interviews with the companies, regulators and other agencies; and workshops with business partners. In total, 21 semi-structured interviews were undertaken in the ADAPT project. Two workshops were held with business partners, together with two Advisory Panel meetings. Through the project, further

contacts were made with business partners. A further 20 interviews, using an equivalent interview protocol, were conducted in the associated study, carried out by the SPRU team, to develop a climate adaptation toolkit on behalf of Yorkshire Forward.¹

The main dissemination event was a conference titled *How can business adapt to climate change?*, organised with support from the Tyndall Centre in London in June 2003. The conference featured academic, industrial and policy speakers and attracted about 50 delegates. A project website, two newsletters and two progress reports for business partners and the Advisory Panel were also produced. One peer-reviewed journal article has been published and three are currently in preparation.

The project had planned to conduct parallel case study research in two other European countries. After an exhaustive survey of potential interview partners in France, Germany and the Netherlands, it proved impossible, even with the support of trade associations, to carry this work out in the housing sector.

Results

The study developed a theoretical framework that sees organisational adaptation as a learning process that was empirically-grounded in work with partner companies. Organisations respond to signals about actual and potential impacts of climate change on their operations in the context of many other more powerful signals about their market environments. Organisations attempt to apply existing ‘routines’ (ways of doing things, technologies, norms and so on) in response to these signals. It is only when these routines are recognised to be inappropriate or failing that the organisation invests effort in innovating new routines and articulating these in its practices. At this point it seeks to find evidence, through feedback, about the success, or otherwise, of its new ways of doing things. Using this model, it becomes clear that business organisations face a number of fundamental problems in learning how to adapt to climate change impacts. These problems include:

1. *Signal recognition.* Organisations may find it difficult to recognise and interpret climate change stimuli.
2. *Experiential learning.* Because of the weakness and ambiguity of climate change stimuli, it is unlikely that trial-and-error experimentation around standard operating routines will play a significant role in all but extremely climate-sensitive organisations.
3. *Link between adaptation and performance.* In the process of narrowing down and choosing adaptation strategies, organisations will face difficulty in assessing and codifying the advantages of new routines.
4. *Feedback.* Where adaptations are made, direct measurable feedback on the organisation confirming the value of adaptations will often be absent. The principal feedback will again be indirectly through the behaviour of other actors (customers, regulators and creditors).

This learning model of adaptation was applied in the development of a decision-making framework for companies. This provides for a 4-stage process for companies to follow: a risk and opportunity analysis; strategy setting; implementation; and integration. Background work for this study confirmed problems of signal recognition, options appraisal and feedback highlighted in our empirical research. The decision-making framework is now being piloted with companies in the Yorkshire/Humber region, results of which will be launched in 2004.

¹ ‘Climate Change: Developing a decision-making support framework for the Yorkshire and Humber region’

The project was not able to make progress on a set of adaptive capacity indicators for companies. The main reason is that adaptive capacity appears to be a property of an organisation, as well as the social and economic context in which it is operating. These contexts are often quite specific, so that defining and constructing indicators of adaptive capacity at the organisational level that are in some senses comparable and useful may not be possible.

Relevance to Tyndall Centre research strategy and overall Centre objectives

The project has contributed to Theme 3 on adapting to climate change, which is seeking to develop a better understanding of processes of adaptation and developing tools for decision-makers. We believe that the project has made a significant contribution to understanding how problems of uncertainty and timing are likely to be dealt with by adapting agents, such as businesses.

Potential for further work

This project was intended as a preliminary study, opting for a detailed study of a few organisations in depth in order to develop and test an analytical framework. Having established a theoretically-grounded framework, we believe there are a number of directions in which our research could go:

1. To develop broad-scale sectoral and regional assessments of vulnerability and adaptive capacity.
2. To apply techniques such as agent-based modelling to adaptive behaviour by business organisations, in tandem with a participative research process involving stakeholders.
3. To apply ‘option value theory’ in the economic assessment of adaptation measures available to companies and sectors.
4. To investigate more carefully the interaction between policy frameworks and the adaptive capacity of organisations, given that regulatory frameworks are important both in signalling the need to adapt and in acting as a constraint on adaptation.

The work reported here is particularly relevant for subsequent Tyndall projects T3.33 ‘Climate change and water supply planning’ and T3.34 ‘Theory and practice – economic analysis of adaptation’.

Publications

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Technical Report

1. Conceptual developments

1.1 Organisational adaptation as a process of learning

A substantial academic literature has been developed on adaptation and related concepts such as sensitivity, vulnerability, resilience and adaptive capacity (Burton, 1996; Downing et al., 1996; Yohe et al., 1996; Glantz, 1998; Tol et al., 1998; Schneider, 2000; IPCC, 2001). However, progress towards developing theoretical understandings of adaptation has been slow (Kasperson et al., 1995; Kelly and Adger, 2000; Folke et al., 2002). Existing accounts draw on frames, methods and taxonomies borrowed from a range of disciplines including conservation ecology, welfare economics, and hazards and risk research. Although efforts have been made to develop common definitions and generic prescriptions, especially through the Intergovernmental Panel on Climate Change (IPCC) and in national assessment processes, these have not yet generated a coherent conceptual framework or a clear research agenda (Smit et al., 2000; Parson et al, 2003). The aim is usually descriptive (listing the factors that may influence adaptive capacity, for instance) or normative (making recommendations about the role of policy in enabling adaptation), rather than analytical, so that it is not yet possible to answer fundamental questions like: What are the attributes of the adaptive capacity of specific communities, organisations and resources? What motivates adaptation processes? What factors determine processes of adaptation?

The ADAPT project aimed to develop a framework for analysing adaptation to the direct and indirect impacts of climate change on organisations. Organisations such as business firms are the primary social units within which processes of adaptation will take place, even if their vulnerability and adaptive capacity will be profoundly influenced by the market and regulatory contexts within which they operate. Our analysis takes the perspective of the organisation, and views ‘climate stimuli’ as one among many stimuli for change that the organisation will face.² This contrasts with much climate-related literature on adaptation which takes as its starting point climate stimuli, making an implicit assumption that some form of adaptation is likely to be induced by them (cf. Smit and Pilifosova, 2001).

Our aim has been to take a more organisation-centred view of adaptation that looks at processes of adaptation in business firms. We believe that issues of perception, sense-making, interpretation and problem-solving are central to determining whether and how adaptation amongst social agents takes place. Our objective was to develop the means to influence the adaptive strategies of organisations. We also aimed to contribute to the debate about the assumptions about agent strategies used in integrated assessments (cf. Schneider et al, 2000).

² Climate stimuli are those features of climate that have some influence on the behaviour of a system. So, for instance, mean daily temperature is a stimulus for ice-cream sales.

Drawing on evolutionary theories of economic change and organisational learning literatures, we argue that processes of adaptation involve changes to organisational 'routines' (Nelson and Winter, 1982). Routines represent much of an organisation's on-going activity and they come to be challenged and adjusted in processes of learning. We further argue that many of the characteristic signals and mechanisms that play a role in market-induced organisational learning and change are absent with regard to adaptations that may be made in response to climate change stimuli. This has implications for how adaptation processes are likely to unfold, and draws attention to the importance of the adaptive capacity that is available to organisations by virtue of their own resources and the context within which it operates.

1.2 Organisational learning

Theories of organisational learning draw on behavioural studies of organisations and have traditionally been concerned with the question of why and how organisations change their behaviour. The work has mainly been concerned with understanding how organisations learn from direct experience, how they learn from others, and how they develop conceptual frameworks for interpreting that experience (Levitt and March, 1988: 319). Learning involves the encoding in organisational routines of lessons learnt from experience and leads to changes in organisational behaviour - a process often referred to as adaptation (cf. Chakravarty, 1982; Aldrich and Auster, 1986; March, 1991; Staber and Sydow, 2002).

1.2.1 Routines

The notion of routines is at the heart of behaviour studies of organisations (Cyert and March, 1963; Nelson and Winter, 1982). Routines are the means by which organisations carry out activities by matching appropriate procedures to situations they face, whether ordinary or extraordinary. This process of matching generally does not involve rational choices between alternatives, but is rather the enactment of processes that are seen as suitable and legitimate given a recognised set of circumstances. Routines include a wide variety of phenomena: rules, procedures, strategies, technologies, conventions, cultures and beliefs around which organisations are built and through which they operate. At any one moment, the routines enacted by individuals and subunits in an organisation are those that have been selected as being advantageous through a process of experience and learning. These activities, which are geared to the operational functioning of the organisation, have been referred to as operating routines (Zollo and Winter, 2002: 340). Routines are modified or adapted when the organisation experiences novel situations for which appropriate procedures have not yet been developed, when existing routines prove to be unsuccessful, or when alternative routines which promise greater advantages are discovered internally or externally (Gavetti and Levinthal, 2000). In these situations, routines are adapted incrementally in response to feedback about outcomes (Steinbruner, 1974). However, this process of modification requires special effort on the part of the organisation and a specific set of capabilities.

1.2.2 Operational and dynamic capabilities

Two types of capabilities are commonly referred to: operational capabilities are those that enable a firm to carry out its routine business activities; and dynamic capabilities that enable a firm to change and adapt operational activities (Collis, 1994). Dynamic capabilities involve the ability to integrate, build and reconfigure internal and external

competencies and routines (Teece et al., 1997). Zollo and Winter (2002: 340) define a dynamic capability as ‘...a learned and stable pattern of collective activity through which an organisation systematically generates and modifies its operating routines in pursuit of improved effectiveness.’

All organisations are seen as possessing dynamic capabilities, although the appropriate investment of resources in these capabilities may vary depending on the perceived benefits arising from them. Sometimes dynamic capabilities will be too costly to maintain. In general, organisations operating in stable environments are assumed to focus on efficiency gains through improvements of operating routines, while in less stable environments greater investments are made in exploration and the discovery of new ways of doing things (March, 1991; Benner and Tushman, 2003). It is important to recognise that learning processes are deemed to apply to both operating routines and to dynamic capabilities.

1.2.3 Signalling and interpretation

In studies of organisational learning, change in routines comes about in response to direct organisational experience. However, before process change can be initiated there needs to be a signalling mechanism bringing recognition that a novel situation has been experienced and that existing routines are inappropriate or ineffective. One of the main conclusions from research on sense-making in organisations is that interpretations of experience depend on the frames of reference within which that experience is understood (Daft and Weick, 1984). There is generally a resistance to drawing conclusions that challenge these frames of reference so that organisational myths, beliefs and paradigms are maintained, often in the face of considerable counter-evidence. Evidence derived from experience is more likely to be recognised the more frequent, unambiguous and salient it is to an organisation. The research identified a range of reasons why the evidence from experience may fail to be recognised and interpreted as significant. These include scarcity of evidence, blindness to evidence, and uncertainty in assessing the relevance of evidence.

1.2.4 Experimentation and search

Two different mechanisms are described in the process of initiating an adaptation of organisational routines: trial-and-error experimentation and search (March, 1991; Nelson and Winter, 1982). Trial and error relates to semi-automatic stimulus-response processes and the mainly tacit accumulation of experience that occurs incrementally through the enactment of operating routines (Zollo and Winter, 2002: 341). This process has been observed in practice and modelled using the idea of learning curves, but is not much further discussed. Processes of search involve an exploration of alternative ways of responding to novel situations, and are seen as being constitutive of dynamic capabilities. This is a creative process involving internal and external scanning for relevant experience and knowledge that can be applied and recombined in an effort to generate a variety of adaptation options (Nonaka, 1994).

1.2.5 Knowledge articulation and codification

Adaptation options are exposed to an internal selection process that identifies a subset deemed appropriate and legitimate for the organisation. This involves an evaluation process through collective discussions and internal or external assessments. A critical aim is to reduce causal ambiguity that frequently exists

between adaptation options and their performance implications (Lippman and Rumelt, 1982). This selection process is succeeded by a higher level cognitive effort in which modified routines and their performance implications are codified in manuals, blueprints, decision-support tools, software, targets and so on. This process of codification is necessary because it enables the transmission of the adaptation and its justification throughout the organisation and the replication and enactment change processes. Codification is resource-intensive because it requires abstraction and working through situations in which new or reconfigured routines should be applied.

1.2.6 Feedback and iteration

Organisational learning can be seen as a cycle which begins with a stimulus leading to the generation of variation through experimentation and search, proceeds with a process of internal selection, articulation and codification, followed by replication and adoption of the adaptation across the organisation, finally returning to the beginning of a new cycle of innovation by virtue of a new stimulus. Throughout this process between the initial stimulus and the broad application of a new routine there is an assumption that evidence from experience will continue to validate it. This happens through processes of feedback that continue to show that the adaptation is seen as an effective way of responding to experienced situations, and because it is perceived to be leading to performance benefits. A schematic of an organisational learning cycle is presented in Figure 1.

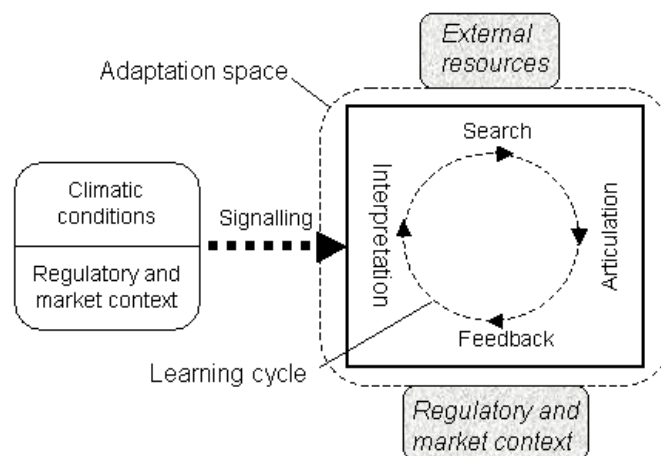


Figure 1: A learning model of organisational adaptation to climate change

An organisation, represented by the box, receives signals about their environment (economic, political and physical), to which it responds by instituting routines. Changes to routines are made in the context of the ‘adaptation space’ (the universe of existing adaptation measures), and adaptation processes depend on external resources and the regulatory and market context.

1.3 Summary

Using these ideas we can restate the problem of organisational adaptation to climate change impacts. Operating routines represent activities that are appropriate across the coping range of an organisation. The limits of the coping range will be defined by those situations for which no operating routine is available, and where routines need to be modified or new ones developed. Interpretation from experience of climate change stimuli has some special features. Not only is evidence of change ambiguous

(the problem of signal to noise), the stimulus will often not be experienced directly by the organisation. In addition, interpretation of signals will frequently depend on the advice of external specialists who may not be able to provide clear and definitive answers. Advice may therefore not come in a form that translates easily to the experience and routines of the organisation.

The process of adaptation is also likely to have distinct features. Opportunities for 'trail-and-error' adaptation may be relevant to sectors like agriculture and water services in which climate sensitivity translates fairly directly into organisational performance. But we would expect these to be less common in less climate-sensitive sectors organisations because the conditions under which 'errors' could be identified may not exist. In these sectors a search and assessment process is likely to play a key role, suggesting also that the process of adaptation will be managed by higher-level functions in the organisation. Given prevailing uncertainty, there are likely to be benefits in cost and risk sharing and in collaborative learning between companies.

Likewise, knowledge articulation and codification will be expected to pose special challenges because of the causal ambiguity between adaptation options and their implications for organisational performance (in the short and long term). In the absence of a clear climate signal it will be difficult to identify those options that lead unambiguously to greater organisational effectiveness. Finally, we would expect the feedback mechanism - demonstrating the benefits of an adaptation option or strategy - to be weak in many cases. This is because average climatic conditions are likely to change only slowly compared with learning cycles typical in organisations, and because examples of more extreme events are likely to be rare. Even if such events do remove ambiguity about climate signals and precipitate action, they may not, by themselves, generate sufficient evidence with which to justify and calibrate adaptation measures. Responses in reaction to extreme events may often be extreme. Much feedback is likely to be generated indirectly through appraisal processes such as risk assessments that deal with hypothetical, rather than measurable performance.

We have highlighted a number of key problems related to organisational adaptation to climate change. These include:

1. *Signal recognition.* Organisations may find it difficult to recognise and interpret climate change stimuli. They will in many cases depend on external pressure, advice and expert assessment.
2. *Experiential learning.* Because of the weakness and ambiguity of climate change stimuli, it is unlikely that trail-and-error experimentation around standard operating routines will play a significant role in all but extremely climate-sensitive organisations.
3. *Link between adaptation and performance.* In the process of narrowing down and choosing adaptation strategies, organisations will face difficulty in assessing and codifying the advantages of new routines.
4. *Feedback.* Where adaptations are made, direct feedback from the climate confirming the value of adaptations will often be absent. The principal feedback will again be indirectly through the behaviour of other actors (customers, regulators and creditors).

2. Empirical results

2.1 Methodology and rationale

The aim of the empirical part of the study was to:

- assess how companies can adapt to climatic changes that affect their sector
- understand the determinants of adaptive capacity of companies
- explore how adaptive capacity of companies may be measured by qualitative and quantitative indicators.

Previous impacts studies have shown that climate change will have very different effects in individual economic sectors. House building and water services were chosen as the two case study sectors on the grounds that both are considerably affected by climate change while also having very distinct features (e.g. market structure, customer base, degree of regulatory intervention, planning horizon).

The institutionalist perspective of the ADAPT study required the establishment of close working relationships with organisations enabling the research team to gain detailed insights into their attitudes, capabilities, operations, culture and institutional settings. It had therefore been decided to restrict the sample of case studies to a relatively small number, while consciously choosing a very different types of companies to capture some of the diversity of the sectors. The research in the two sectors was carried out in parallel, employing an identical interview approach (background research, semi-structured in-depth interviews with employees from different parts of the company, additional interviews with a small number of other key actors in the industry).

2.2 Housebuilding

This case study sample consisted of five UK house-building companies: two housing associations (one London-based, one in the South East), a large national commercial developer, and two smaller, more specialised commercial developers. A total of 17 semi-structured in-depth interviews were carried out with employees representing different parts of the five case study companies (e.g. the development manager, technical manager and construction director).

2.2.1 Climate change awareness of house builders

There was a general awareness that a changed climate could become a significant issue for the sector, but this was largely based on general media coverage, rather than specialised information sources or immediate observation by the firm. The companies interviewed had not attempted to identify the specific impacts which climate change could have on their business. Climate change was seen as an issue on the horizon, rather than something that required action at present. While some interviewees thought climate change could present a major threat to aspects of their business, others expressed the view that problems would be solved through well-understood technological measures. There were a small number of issues about which some companies are very aware, e.g. increased flood risk, higher skin cancer risk for the workforce on building sites and a possible increase in the demand for air conditioning.

2.2.2 Potential impacts of climate change on house builders

Interviews revealed a wide range of potential climate change impacts, but what individuals considered the most important impact depended on their role within the organisation, as well as on the market segment in which the company operated. For example, while a strategic land manager in the south of England was most worried about increased flooding, a technical director of a company operating in London was more concerned about changing demands for heating and cooling in buildings. These results appear to demonstrate both the specificity of the pattern of impacts, as well as the lack of an operational consensus within the industry.

Rather than posing distinct or novel problems for house builders, impacts of climate change were usually seen as adding to existing pressures on house builders. Reluctance of customers to buy properties in floodplains, for example, represents an additional constraint on the search for land suitable for development. The strength of this pressure was seen to depend on the pace and magnitude of climatic changes and the behaviour of regulators, suppliers, and customers.

Direct impacts

In general, we found that the perceived exposure of house builders to *direct* effects of climate change was relatively limited. It was thought likely that changing weather patterns would mainly affect the construction process. Although the building process has always been to some extent weather dependent, wetter autumns and winters could disrupt construction work more frequently. Similarly, higher winds would increase the number of days during which cranes could not be operated and damage building-materials stored on site.

Liability for damage to houses after sale is currently limited to a period of 10 years after completion. Because very considerable climatic changes are not expected over this period, new buildings should not be adversely affected by weather conditions over that time scale, except in the case of major extreme events. However, weather trends may expose instances of poor build quality and design and specification may in some cases prove inadequate. But even if this were the case, the developer will not always be affected, especially if the liability lies with the contractor, supplier or surveyor. If claims were made against the housebuilder, these would normally be covered by the building warranty insurance. Housing associations appear to be more vulnerable to direct impacts than commercial developers because they maintain stock, as well as building new houses.

Indirect impacts

Indirect impacts could be more important than direct weather effects, especially for speculative house builders. Most interviewees held the view that house builders would be affected by two main drivers: regulation and customer demand. Recent flooding events have shown that both drivers can have a powerful impact on the sector. Planning authorities are already taking concerns about flood risk seriously, but some interviewees thought that customers' unwillingness to buy properties in areas at risk from flooding make some development schemes *commercially* unviable. The potential influence of lenders and insurers was also emphasised by several respondents.

Although future flood risk is the major concern for most house builders, interviewees identified a range of other potential indirect impacts. First, climate change was seen to reinforce current attempts by the regulator to mitigate greenhouse gas emissions. Similarly, regulatory bodies, as well as private water companies, could press house builders to introduce new measures aiming to save drinking water and reduce discharge of sewage. New standards for improving the long-term ‘climate-resistance’ against wind, flooding, and driving rain could be recommended or enforced by the regulator and other standard setting organisations.

2.2.3 Adaptation options for house builders

House building companies can adapt to the challenges of climate change through a wide range of mechanisms, many of them well-understood and practicable. A review of potential adaptation measures suggested that three different modes of adaptation:

Commercial adaptation

A significant minority interviewees expressed the view that climate change could affect the commercial strategy of their firm. This concerned, for example, responses to increased flood risk. A number of interviewees said that their company would choose not to acquire or develop a site if there was a (real or perceived) risk of flooding. Others believed that they would, on the contrary, develop the expertise needed to develop properties in high-risk floodplains: through new flood defence techniques or with building designs that accommodate flooding. Several respondents held the view that climate change could reinforce ongoing commercial trends towards modular systems, prefabrication and improved supply chain management which provides more independence from climatic conditions during construction.

Financial adaptation

Financial adaptation, in the sense of taking account of cost implications of new risks and adaptations, was seen by most respondents as a key element of the majority adaptation measures. Except for changes enforced by regulators, house builders were expected to only make adaptations that have short-term financial benefit. Financial adaptation (increase financial reserves or introducing new accounting methods) was seen to be particularly relevant for housing associations because of their long-term responsibility for housing stock. New insurance provision was not seen as a satisfactory solution because the cost would feed back to the company through higher premiums. Financial adaptation could also take place in land buying. Increased flooding would add to the risk that a developer does not obtain planning consent. To limit potential losses, house builders could seek to move to different contractual arrangements that involve risk- and profit-sharing with landowners.

Overall, the large uncertainty around climate change and its impacts means that the basis for sound decisions on financial adaptation measures is often lacking. This can be expected to contribute to a rather reluctant attitude towards financial adaptation, especially because significant adaptation measures would have to be justified in the internal decision-making process.

Technological adaptation

There was broad agreement that the portfolio of technological options available could, in principle, prevent or mitigate almost any impact of climate change on buildings and

the construction process – with the exception of major extreme events. The important question is whether these technologies are commercially viable (in some cases retrofitting technological solutions will be prohibitively expensive) and whether key actors have incentives to develop and adopt them. The problem of incentives is particularly difficult because the cost of introducing new technological solutions would fall on the developer, while the benefits, such as lower maintenance costs and higher long-term value, would be enjoyed by the buyer and subsequent property owners. Moreover, some technological adaptations would need to be implemented on a larger scale and require cooperation between different actors. A good example is flood prevention, but it also applies to areas such as drainage. In these cases, simple technical fixes (larger drainpipes) are often insufficient because climate change adds pressure to the rest of an already over-burdened system. Local adaptation at sub-system level therefore risks passing damage costs on to others.

2.2.4 The adaptive capacity of house builders

The large majority of interviewees suggested that climate change adaptations would not be principally different from many other strategic choices that companies currently face, and that choices to adapt to climate changes are likely to be entangled with choices to adapt to other external pressures. This recognition allows us to examine adaptive capacity using examples of past adaptations to changing market conditions or new technical knowledge. For example, one firm had in the past decided to abandon plastic window frames, another has shifted to timber frame construction. Both changes occurred for commercial, but they served as an example for the type of adaptation decisions that could be necessary in response to climate change.

The cases of actual or potential future adaptations explored during the interviews suggests that the factors that will enable an organisation to carry out these measures vary, depending on the nature of the measure and the type of organisation. In particular, it is not clear that all organisations will be equally capable of recognising or pursuing a strategy definable as ‘efficient adaptation’. An intervening factor – adaptive capacity – will determine the extent to which companies become aware of their vulnerability, and can evaluate, make decisions about and implement adaptation measures, whether in anticipation or in response to climate change impacts. Adaptive capacity related to an awareness of the need to adapt, the ability to make knowledge-based decisions about measures and the capacity to implement the adaptation process. In contrast to what might be expected, adaptive capacity did not appear to be predominantly an *internal* feature of organisations – at least in the case of UK house building firms. Instead, it seems to be based on a combination of both internal capabilities of firms and on their external relationships.

The main internal features of adaptive capacity were identified as being:

- 1) A thorough and flexible risk management process. In many cases, climate change will be an additional risk factor, which may affect the ability to carry out other organisational functions. Effective adaptation would require integration of climatic considerations into existing risk management processes.

- 2) Strong in-house technical expertise facilitates the process of evaluating, choosing and implementing technological adaptation options. It reduces reliance on specialist consultants.
- 3) Effective internal communication is important to raise awareness within the company about potential impacts of climate change. This would facilitate dissemination of information about emerging issues (e.g. the vulnerability of a certain technique) and appropriate responses to the problem.

The main external features of adaptive capacity were viewed as being:

- 1) Good external relationships with actors that drive the adaptation process. This will increase the time available to prepare for changes.
- 2) Good relationships with actors who help in implementing adaptations, for example specialist consultants, designers, suppliers and contractors.

2.2.5 Adaptation by multiple actors: Dynamics at the sector-level

Due to the diversity of potential impacts from climate change, it seems likely that different patterns of adaptive behaviour will emerge. In some cases, the potential for cost-effective technological adaptation is limited (for example flooding, impact of driving rain on existing stock). As a result, adaptive capacity from an organisational, micro-level perspective is mainly related to the capacity to shift risk to other actors (e.g. from the developer to the land owner; from the insurer to the home owner). Other impacts could be prevented or mitigated by technical solutions at a moderate cost, for example making new buildings cope better with driving rain and hot temperatures. If these changes to building standards were to be required by regulation, cost implications not adversely affect house builders because they could be passed on to customers.

Overall, it emerges that actors at the beginning of the supply chain (suppliers, developers, architects etc) will have a strong influence on the future vulnerability and adaptive capacity of the housing stock, but they will only experience a small part of the impact of climate change. As long as the climate changes incrementally, developers and suppliers would only be affected if adverse weather conditions expose defects within the specific warranty period. Those actors situated towards the end of the supply chain (owners, occupiers, household insurers, mortgage lenders and so on) tend to be more exposed to climate change while exerting less control over technological choices that affect the vulnerability to climate change. This is particularly true for the speculative housing market in the UK, which produces highly standardised products. This mismatch in the incentive structure could lead to a situation where the level of adaptation is considerably lower than would be desirable from the point of view of society.

2.3 Water services

2.3.1 Climate change awareness of water companies

The companies interviewed identified climate change as a 'topical issue' and as a potential driver of change within their business. For the most part, climate change did

not appear to be marked as a *significant threat* to the *present* business environment and was largely perceived as a potentially important issue on the medium to long-term planning horizon (2005-2030). **Uncertainties** surrounding the nature of potential impacts on the water-supply industry have made the prioritization of climate change within the risk management process particularly challenging.

Specifically climate change was identified as something that would **exacerbate existing problems** within the water supply and wastewater businesses of companies interviewed. One company noted that subtle changes that have been taking place within their waste-water business are thought to be the result of recent ‘weather change’ and believe that it is this area of their business that will primarily alert them to future climate change. Likewise a company presently experiencing resource problems with a potential deficit in dry years considers climate change as an extra uncertainty that has the capability to exacerbate their current difficulties.

Water companies were found to be **well informed of recent climate change initiatives** and research programs (eg UK Water Industry Research, UKWIR). Many companies actively participate in UKWIR research and have on-going links with climate-related research programs. As with the building sector, the interview process itself served to **raise awareness of potential resource management issues** within companies and alert decision makers to the areas of business that may be most affected.

At the present time, it is clear that the majority of firm decisions made in relation to climate change by water companies have been associated with the **Climate Change Levy** and **greenhouse gas emissions**. At this stage water companies feel that they are missing evidence as to whether climate change has “arrived” either due to the absence of tangible impacts or because they are unable to recognize them. Companies are also unclear as to the shape of future impacts on their business. With this uncertainty, investment decisions are challenging and the process of making firm decisions, in relation to climate change becomes particularly difficult. For these reasons climate change has often been placed in the “**all too difficult**” box.

2.3.2 Potential impacts of climate change on UK water companies

Interviews identified a wide range of potential impacts on water companies. Whilst there were a number of company-specific impacts, two key concerns prevailed: Firstly **changes in demand patterns** were highlighted, where existing problems with resource distribution, especially at peak times, were thought likely to be exacerbated by climate change. Secondly, **changes to the regulatory system** in response to climate change were perceived as a significant threat, especially with tightening standards constraining an already pressurized supply and wastewater treatment process.

Direct impacts

Direct impacts of climate change on the water supply business were anticipated to affect **water supply** and the **demand for water**, and subsequently the **supply-demand balance**. Changing patterns of demand were highlighted by companies to be of significant concern, especially given current trends of increasing peak demands

that are likely to be exacerbated. Increased peak demand represents a *distribution* rather than a resource problem for water companies.

Additional direct impacts such as sea level rise (resulting in saline intrusion), algal blooms on reservoirs and flooding of abstractions were perceived to be less significant risks. Sea level rise was thought unlikely to pose a serious problem for one company as saline intrusion into coastal aquifers is more likely to arise from over abstraction. Algal blooms were considered a potential issue although there have been few cases of this happening to date and it is subsequently difficult to predict the extent to which these may take place under a modified climate regime. Flooding of abstractions was not thought to be a significant problem as abstraction points for companies interviewed were largely located away from flood prone areas.

Water quality issues associated with turbidity and nitrate levels have been regarded as “potential problems” for one water company until recent years. However, over the last few years these issues have become realities with recent weather change and are seen together with wastewater issues as important indicators of climatic change.

Indirect impacts

Water companies expressed concern about indirect impacts of climate change on the regulatory system. The Environment Agency (EA) and the Office of Water Services (OFWAT) regulate the environmental and economic aspects of the water industry in England and Wales respectively. In addition the Drinking Water Inspectorate (DWI) regulates and prosecutes water companies on their adherence to Drinking Water quality regulations.

The environment agency regulates water quality in rivers, abstraction and water resources, sewage sludge (biosolids use), sewage treatment and discharges and bathing waters compliance. Following the drought of 1995 the water industry underwent a series of reviews, which culminated in the 25-year planning framework for the water industry. In 1999 the Environment Agency launched their National Water Resources Strategy and also their Catchment Abstraction Management Strategies (CAMS), which are presently being implemented. The Water Resources Strategy was developed to look 25 years ahead at the water resources situation in England and Wales and is highly interconnected with water company management. Each water company is required by the agency to publish an annually reviewed Water Resources Plan for the 25 year period which plans is then reviewed and modified by the Environment Agency in collaboration with the water company. A key aspect of the Water Resources Strategy is to address how climate change should be responded to. The Environment Agency’s stance is predominantly orientated towards **demand management** opposed to supply-side approaches:

*...we will prefer solutions and strategies that allow flexibility in the face of uncertainty and will **encourage water users to adapt to climate change over time.***

In contrast, the water industry largely believes resource developments should be their primary adaptation option in light of climate change³ and emphasises the **importance of capital intensive resource developments** such as increased storage projects and the development of water transfers from the north. Interviews identified that these conflicting standpoints will indirectly impact the future development of water companies if companies can not obtain regulatory approval for future structural resource developments.

In addition to the Water Resources Strategy for England and Wales the Environment Agency is responsible for Regional Resource Strategies (effectively setting out regional goals for water resources management), drought plans, and Catchment Abstraction Management Strategies (CAMS). Unlike Water Resources Strategies, which evaluate demand and subsequent management options, CAMS detail *availability* at the regional level and inform Regional Resource Strategies. The CAMS process – introduced in 2001, operates on a six-year review cycle providing a backdrop for time-limited abstraction licenses. CAMS were designed to facilitate a balanced relationship between the abstraction requirements of the water industry (and other abstractors) and the water requirements of the aquatic environment. Initial interviews suggested that water companies were **concerned about the potential repercussions of CAMS** for their future ability to supply water and interviewees believed that **tightening standards** associated with the process response could significantly impact their existing and future abstractions.

Regulatory responses to the reduction of summer flows under climate change are of particular concern for water companies. Some environmental groups believe that any reduction to environmental protection as a result of climate change would be totally unacceptable and that water company abstractions should be restricted under such circumstances. Water companies, on the other hand take the view that **change is inevitable** and are keen to find ways in which water can be abstracted whilst maintaining critical flow levels. Interviewees expressed concern that the former argument would gain weight under the CAMS process.

The Director General of Water Services conducts the economic regulation of the water industry through OFWAT. Prices to water company customers are reviewed every 5 years and water companies submit plans to OFWAT detailing and justifying their resource schemes and how their supply systems will be managed. The Director General of OFWAT subsequently reviews water company proposals and sets prices accordingly. In seeking to ensure value for money OFWAT are reluctant to see increased investment in large capital programs and the reflection of such in prices. As a result water companies have been borrowing increasing sums of money to fund such investments. The annual and environmental reports of UK water companies argued that customers would be prepared to accommodate small increases in or maintenance of existing prices to pay for environmental improvements and greater security of supply under climate change. Interviewees recognised however that customers would be satisfied if prices remain at present levels for the near future, but would be less tolerant of any increase. Water companies believe that the **disagreement between water companies and OFWAT** will only be reinforced in anticipation of, and in the

³ Based on environmental and annual reports of the UK's 24 water and sewerage companies.

event of, climate change. Water companies will need to maintain investor confidence and look towards capital programs that address potential resources shortfalls, whilst OFWAT will maintain its current view and argue that environmental and efficiency improvements are paving the way for sustainable performance within the industry *without price increases* being required.

2.3.3 Adaptation options for water companies

Commercial adaptation

The adaptation process may influence the commercial strategy of water companies. Primarily water companies are in the business of supplying water and treating wastewater. Under a changing climate it is difficult for water companies to reduce their exposure to the direct impacts of climate on resource availability through strategic measures. Unlike housing companies who may *choose not to acquire or develop a site* water companies are providing a service. Water companies stressed that their primary objective was to satisfy customer needs. This has recently been enforced through OFWAT's latest guidelines of levels of service.

Consumer marketing strategies are on the other hand viable commercial adaptation options to the direct impacts of **changing customer demand patterns**. These strategies have received mixed reportage in the annual and environmental reports of water companies and were the focus of some debate amongst interviewees. One water company stressed the importance of water metering (in itself a technological adaptation) in demand hot-spots. Various marketing strategies have been focused on increasing their adoption rate. However, the promotion of water efficiency was given less priority by this company, as it is believed that customers will only use water more efficiently once water is metered. Another company expressed the view that marketing strategies only have limited impact – especially those geared towards water efficiency. It is recognised that customers feel that they should not be stopped from using the resource since the industry has been privatised and since the average water bill per household has gone up.

Financial adaptation

Financial adaptation is a relevant process for water companies especially as it may be seen to encompass adaptations that become real options because of their financial viability. Specifically, it was clear from interviews that adaptation measures would only be seriously considered if they were **economically justifiable** to the board and to the shareholders. Further interviews should ascertain whether a wider set of financial adaptation measures is available to water companies.

Technological adaptation

Technological adaptations were by far the most extensive group of options considered by water companies in response to climate impacts. Predominantly resource developments were suggested as the main response option, however it was stressed that **resource developments** are not easy and any decision to enhance the existing supply system would pass through an extensive in house and regulatory appraisal process. Increased climate variability was translated by one company into a need for reservoirs to be kept full for longer. Climatic variability has been managed to date by this company through the use of “double season” opposed to “single season” systems.

Double season systems buffer the impact of annual irregularities in supply and were reported to be a fundamental adaptation to present variability in weather.

The enhancement of existing sources through **purchasing bulk water** from other water companies was also seen as a highly feasible adaptation measure. This option would be used to address distribution related issues thrown up by peak demand patterns as well as potential resource problems.

Leakage reduction was suggested as a process that is indirectly operating as a technological adaptation at the present time. For one water company, leakage reduction is presently balancing increased demand and is thought to continue to do so into the near future. However, it was widely agreed that this would not always be the case where further reduction in leakage would be highly expensive and only make small adjustments to the company's overall percentage leakage rate. At this point additional technological options would be required to address demand. Extreme measures such as **desalination** were not completely ruled out by interviewees, however the financial viability of such would be the determining factor. Clearly present *uncertainty* about the nature and timing of climate change does not lend itself to the serious consideration of costly technological adaptations at this stage.

It should be stressed that a large number of potential technological adaptation options available to water companies are dependent on **regulator appraisal**. One water company considers a key future technological adaptation to be the abstraction of excess flow from rivers (excess being river flow available on top of that specified as necessary for habitat preservation etc.) However, this potential adaptation is primarily dependent on the agreement of the Environment Agency and like similar issues, is subject to some debate at present.

Interviews ascertained that resource developments and the methods by which they are appraised will largely follow the existing format in future water company adaptation to climate change.

Information and monitoring

The water companies interviewed to date demonstrated a high degree of awareness about climate change. Commitments to reducing greenhouse gas emissions under the climate change levy were widespread, however, there was significant uncertainty as to the specific impacts of climate change on their business and subsequently little consensus on the areas that would be most appropriately monitored to ascertain future impact. It is thought that demand monitoring may be a more measurable indicator of change than supply, however, it is unclear as to whether this will be sufficient for the informational needs of future adaptation programs.

Influencing the regulators

Perhaps one of the most significant adaptation options available to water companies in light of the indirect impacts of regulatory change is to increase their involvement in the regulatory process and argue their position through ongoing consultation response and lobbying. Interviewees stressed that they would seek to be heard in any regulatory decision process that affected their ability to supply and treat water. The

following section discusses how the utilisation of this option by companies would increase their adaptive capacity.

2.3.4 The adaptive capacity of water companies

The concept of organisational adaptive capacity has largely been explored with respect to the overall outcome of the decision making process culminating in:

1. The ability to make changes to avoid new risks arising from climate change
2. The capacity to recover from losses stemming from climate impacts
3. The capability to exploit new opportunities arising from adaptation

As outlined in the December progress report this project seeks to explore the *processes* behind organizational adaptive capacity, where features of the organization and the context within which it operates are understood in relation to the adaptation strategy that it adopts. The concept of an “adaptation space” has been identified to describe the area where clusters of adaptation options relevant to an organization are available and how these interact with the formulation of an adaptation strategy.

Research within the water sector **reinforced the appropriateness of this framework** for understanding the organizational adaptation process. In particular it was evident that a conceptual framework was needed to describe the way in which external and internal organizational forces interact with the range of adaptation options available to a company and its overall adaptation strategy. It became clear that the “ultimate adaptation option” was a somewhat unrealistic mechanism for describing the water company adaptation process as organisations had a large number of options sets available to them. The process of organizational adaptive capacity was found to be extremely meaningful in itself, however extremely challenging to describe.

Interviews identified that early adaptations to climate change made under present levels of uncertainty were **not** likely to be **significantly different from other strategic decisions** made by the company, both in terms of the decision making process and the resource development process. However at a later stage of the adaptation process interviewees entertained the possibility that more extreme adaptations may take place. For example, desalination as a technical resource development was considered a plausible long-term adaptation in the event that leakage reduction could no longer compensate for increased demand with climate change. It became clear that the adaptive capacity of water companies was dependent on not only their internal capabilities but their external relationships with regulators, other companies within the sector, NGOs and government.

Internal characteristics of adaptive capacity

A key internal characteristics of adaptive capacity for water companies was identified (on the basis of interviews conducted to date) to be the degree of inherent flexibility within the organisations strategic decision making process. Flexibility has been well reported in the literature to be a fundamental characteristic of an effective adaptation strategy and it is clear that an organisation with a degree of flexibility built into processes such as risk management, should develop more effectively in light of climate change.

A second important internal characteristic of adaptive capacity within water companies is **awareness of climate change**. This awareness should encompass a range of factors, from an understanding of how climate change could affect their business to an appreciation of monitoring options and internal indicators of change within their network. Links with the science base and with **industry research** organisations were identified to be an important mechanism for **communicating science to management**. Likewise, communication within the company between technical and strategic management levels was identified as a highly important characteristic of an adaptive organisation.

Thirdly an organisations **existing resource situation** was identified as an important control over its adaptation potential. Where an organisation is encountering resource pressures under present climate its adaptation space – with packages of options available for a climate driven adaptation process – is likely to be somewhat limited and subsequently may constrain the level and nature of future adaptations. However, it should be noted that an organisation facing resource pressures at the present time may indeed develop its adaptive capacity further at an earlier stage due to existing circumstances alerting decision makers to future climate related risks.

External aspects of adaptive capacity

A number of external characteristics were identified as relevant to a water company's adaptive capacity. Firstly a sound relationship with the water industry regulators – the Environment Agency (EA) and the Office of Water Services (OFWAT) was deemed essential for any adaptation process to be meaningful and successful. Related to this, interviewees stressed the importance of their involvement in the regulatory process concerning abstraction licenses for example, and the degree to which they are given the opportunity to express their views concerning key matters.

Interviewees also expressed the opinion that the regulatory process needs to be much more **transparent** and emphasized the importance of clear time horizons for effective planning and risk management procedures. The decisions that regulators make with respect to matters such as approving an organisations water resources plans and abstraction licenses are clearly a fundamental external influence on that organisations adaptive capacity. The factors that influence these decisions are therefore in themselves important external controls. Government policy, the economic climate and environmental objectives within Europe will all subsequently influence the adaptation options and adaptation strategy that a water company chooses.

2.4 Synthesis

Our case study into impacts, adaptations and adaptive capacity in the UK house building sector suggests that this approach incompletely describes processes of adaptation as they occur in the real world.

It is important to recognise that, from the point of view of companies, climate change is (and will remain) only one factor that influences strategic decision-making amongst many others. Climate-related adaptations will be made against the background of a number of other, perhaps more important, drivers of change: changing technologies, shifting consumer expectations, emergence of new competitors, changing regulations and so on.

We also argue that it would be unrealistic to expect that adaptation decisions will be made on the basis of extensive information and an elaborate risk assessment process. Adaptation processes are likely to correspond to a model of *satisficing*, rather than *optimising* behaviour by organisations. This is mainly due to multiple uncertainties, differing strategies pursued by interacting organisations, and unclear and sometimes mismatched patterns of incentives for adaptation. The capacity to adapt will depend not only on factors internal to an organisation, but also the broader institutional, market and cultural context within which they operate. People and organisations in climate-sensitive sectors face uncertainty about the significance of climate changes to their activities and about the best way to respond to these risks. As a result, it will often be impossible to determine ‘optimal’ adaptation options. Organisational adaptations will always include elements of uncertainty, choice and strategy. Whether a company chooses to be proactive or reactive; to take risks or to avoid them; to think long-term or short term, is not primarily a question of whether adaptation options exist whose outcomes are unambiguously predictable *ex ante*.

While we agree with the proposition that many adaptation measures are available in principle - a wide ‘adaptation space’ - we do not believe that these measures are best seen as discrete and well-defined options. Most adaptations require chains of adjustment and innovation, and complex management processes in areas such as design, project planning, choice of suppliers and logistics. Some of the examples (pre-fabrication) examined showed that adaptation can be closely linked to broader technological and commercial trends and that it is not always possible to disentangle climate-related and non-climate choices, decisions and changes. In other cases (development of riverine flood plains), the obverse is true and adaptations that could bring benefits to the company, in terms of reduced vulnerability or greater adaptive capacity, run counter to prevailing trends.

In the companies studied, we conclude that adaptation is a process characterised as:

- motivated by both direct and indirect signals;
- based on both internal capabilities of the firm, as well as the regulatory, market and climatic context within which it operates;
- involving poorly-defined choices between complex sets of measures, often made up of chains of adjustments that may involve several actors;
- including the implementation of both anticipatory and reactive measures;
- involving a variety of risk management strategies, including risk bearing, risk sharing, risk shifting and risk avoiding.

Much adaptation by firms will be taken up with the challenge of learning how much adaptation space is available to them and which adaptation strategy is most appropriate to their internal capabilities, corporate goals and market and regulatory context.

Our results shed light on the adaptive behaviour we can expect to see from companies and demonstrate some of the dynamics associated with the interaction of adaptation strategies pursued by different actors in climate-sensitive sector. Rather than perceiving the response to climate change as a largely technological challenge, our

research has focused on the behaviour of the different actors involved in adaptation: their perceptions and incentives, the constraints they work under, and the relationships between them. The case studies confirmed our hypothesis that this depiction of adaptive behaviour does not adequately reflect decision-making processes about adaptation as they are likely occur in the real world. In the companies studied, we found many indications that adaptive behaviour will correspond to the model of bounded rationality⁴:

- although organisations have available to them a potentially wide set of opportunities to adapt, their ability to implement them is severely constrained by a range of factors (e.g. lack of incentives, scientific uncertainty, regulatory and market context)
- if confronted with a climate change scenario, interviewees (including employees who work for the same company) have expressed very different views about whether, how and to what extent these could affect their business
- companies are responding very differently to climate-related challenges, demonstrating that adaptation decisions involve an element of strategy (shaped, for example, by the organisation's attitudes to risk, its organisational culture and capabilities).

Assuming rational behaviour is also problematic because many British companies will be affected by climate change indirectly, rather than directly through weather condition, for example through changing customer demand or new requirements from the financial sector. These indirect effects are very difficult to anticipate or assess because they tend to result from a range of dynamic, interdependent and often unpredictable responses to climate change.

Furthermore, potential responses can in many cases not be characterised as clearly defined option sets (e.g. choice of farmer between crop A, B and C). Instead, potential adaptive responses in the two case studies usually involved decision on complex sets of measures, often made up of chains of adjustments and sometimes overlapping or complementary. The planning and implementation of adaptation measures may involve different parts of the company (finance, R&D, marketing etc) as well as external partners (e.g. suppliers, funders).

From the perspective of a business organisation, climate change represents one amongst many (often more important) drivers. Business decisions are made for a variety of reasons and the questions of whether the decision affects vulnerability to climate change will in many cases only be a minor aspect.

Although climate change will be a new source of change, the risks (and possibly opportunities) it poses for companies in Britain are similar to other challenges faced by business. Climate change may force firms to do things differently in the future, but so do new competitors, new technologies, changing exchange rates or tighter regulation. As a result, adaptation will often involve actions comparable to 'normal' market adaptation. At the same time, climate change adaptation has a number of

⁴ An exception to this overall pattern is adaptation by water companies to the anticipated impacts of climate change on water supply, where climate change data and water modelling is employed to forecast future water supply.

specific features, especially the long term nature of change and the need for a particular type of information.

3. Development of a decision-support tool

During the final phase of the project, we have used the insights gained in this research to develop a management tool that can be used by organisations to assess and reduce their vulnerability to climate change.

3.1 Adaptive behaviour of companies: Lessons for management tools

The insights described in the previous section led on to a number of important lessons for the development of a management tool flow:

- Rather than identifying the overall ‘optimal’ adaptation option, the management tool should take account of the specific capabilities of the firm and its market and regulatory context.
- The contingent nature of climate impacts and adaptations also means that a tool can only help an organisation to ask the right question, but will not be able to generate detailed prescriptions.
- A climate change management tool should not attempt to radically alter internal decision-making processes, but it should help to integrate climate change into existing procedures.
- The tool should be simple and flexible, acknowledging the fact that adaptation processes in business are constrained by cognitive, financial, regulatory and technological barriers.
- It should help to identify a wide range of anticipatory and reactive measures and to identify a portfolio of complementary responses.
- The attention of decision-makers should be drawn to indirect as well as direct effects from climate change.

3.2 Aims of a management tool for business adaptation

The term ‘management tool’ stands for a whole variety of techniques, systems, procedures, and methodologies which aim to assist organisations in clarifying or achieving particular objectives. They have in common that they do not provide answers by themselves but present a process of problem-solving and produce relevant information (cf Brady et al 1997).

A management tool for climate adaptation should:

- ⇒ allow companies to explore their sensitivity and adaptive capacity in relation to climate change, thereby providing an overall assessment of vulnerability
- ⇒ enable companies to take steps to become less vulnerable, either by reducing their sensitivity or by increasing their adaptive capacity
- ⇒ support the decisions about the relative risks and opportunities associated with different anticipatory and reactive strategies.

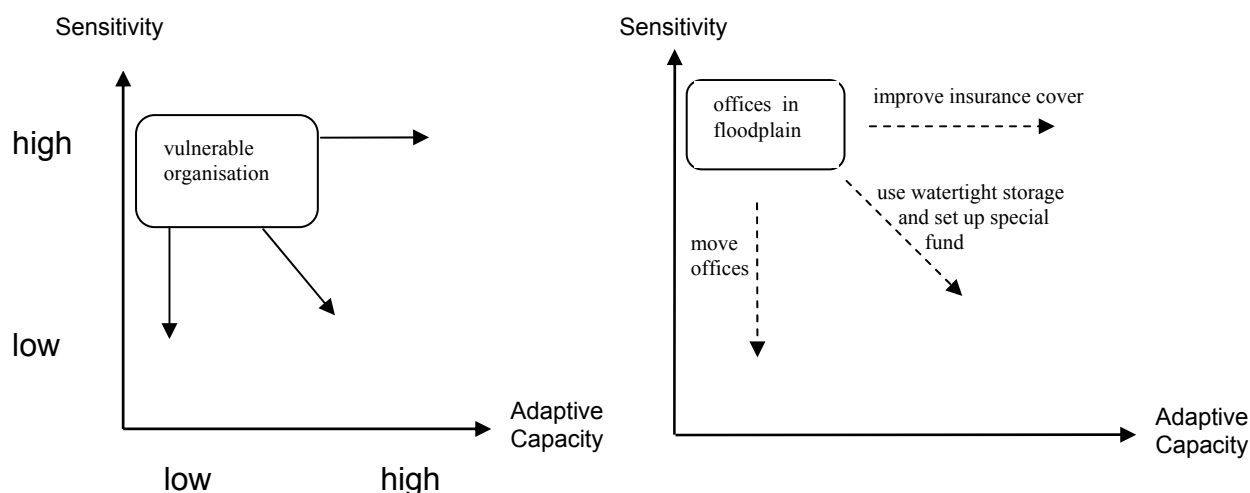


Figure 2: Strategies to reduce vulnerability (and examples)

The main challenge for an adaptation management tool is that climate change impacts will be extremely heterogeneous, depending on the nature of the climatic phenomenon, the economic sector, the business operation concerned and so on. To provide useful guidance to companies, it would therefore be desirable to develop tools that are tailored to the specific circumstances of a wide range of climate-sensitive sectors. In the context of this project, however, we have only developed a generic framework and process for climate change management.

Despite complexity of scientific, technical and financial issues related to climate change and adaptation, it is important to keep the process of using the tool simple because most companies are unlikely to commit very significant resources to an assessment of their vulnerability. Companies should be able to use the materials provided through a process of self-assessment.

Due to the uncertainty about future climate change, its impacts and knock-on effects, quantitative information at a level of detail that would make it useful for decision-makers is largely lacking. Therefore, the tool is essentially qualitative in nature, although it proposes simple quantitative methods at different stages.

3.3 Outline of the Climate Change Management Toolkit

On the basis of these findings and reflections, the research team has developed a framework for a business adaptation management tool during summer 2002. In autumn 2002, the team was commissioned by the Yorkshire and Humber Regional Development Agency to develop a climate change management tool for the Yorkshire region. This project - which has now also been completed - has taken the framework developed by the ADAPT study, expanded and refined it on the basis of additional interviews with potential users, as well as making it relevant to Yorkshire and Humber region. The resulting comprehensive toolkit is currently being piloted with three companies in the region before being disseminated more widely.

As a consequence of this new project, the original ADAPT framework (documented in Haum, Hertin, Berkhout 2002) has been developed further. It therefore appears

appropriate to give a brief outline of the more recent Yorkshire Climate Change Management toolkit (for full report see Hertin , Haum and Berkhout, 2003) rather than presenting the original framework. Although this new work has been carried with funding from Yorkshire Forward, it is conceptually based on the ADAPT research.

The toolkit has three main elements. First, it offers climate-related knowledge relevant to business. Second, it sets out an overall process companies could go through to assess and reduce their vulnerability to climate change. Third, it provides guidance and materials to support the activities that should be carried out in each of the stages (e.g. process guidance, checklists). It has been designed to be used by companies in an unassisted process of self-assessment.

Climate-related knowledge

ADAPT research has confirmed that knowledge about climate change varies considerably between sectors and companies. In sectors where climate change is not seen as a key issue, companies often rely on general media to communicate relevant information. The process of building up and communicating specialist knowledge through sectoral channels (e.g. trade press, conferences) is only just beginning. As a consequence, any business-oriented tool needs to start by providing basic information about climate change and its potential impacts on society and the economy.

The toolkit provides this information, presenting existing information in a form that responds to the information requirements of business. This involves providing a concise summary of the most relevant results of scientific research in readable format and accessible language. The information section of the toolkit includes a short synopsis of climate impacts in individual economic sectors, such as agriculture, tourism, and housing. It also lists references to further sources of information and to organisations that have specialist knowledge in this area.

Process of climate impact management by companies

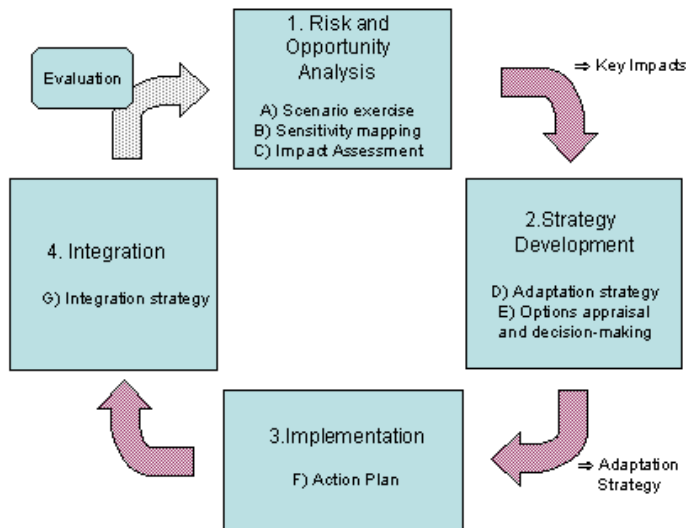
Four key stages in the process of climate impact management by business have been identified:

Stage 1: Risk and Opportunity Analysis aims to identify the business areas that could be affected by climate change - both directly and indirectly. It involves a preliminary review of the key issues, which may be followed up by a detailed analysis to produce a prioritised list of key impacts.

Stage 2: Strategy development formulates an overall strategic approach towards climate change adaptation. It set out strategies to respond to the risks and opportunities posed by each key impact.

Stage 3: The Implementation phase develops an action plan for the strategies developed in stage 2 and supports its implementation.

Stage 4: The Integration phase aims to identify internal processes and routines in which climate change concerns should be integrated.



Seven tools for climate impact management

The toolkit sets out seven different tools that support the four stages of climate impact management. These are:

A. Scenario Exercise:

This part of the toolkit sets out a business-oriented climate change scenario to initiate a brainstorming about potential impacts that could affect the company. The scenario can be used in an internal workshop or by an individual within the organisation.

B. Sensitivity Mapping

A table giving a systematic overview of different areas of potential climate impacts on business presents a starting point to an analysis of vulnerability. The aim of this tool is to produce a 'long list' of potential vulnerabilities. Because the effects of changing weather patterns are very specific to the company and sector concerned, this exercise requires a considerable degree of user input.

C. Impact Assessment

The impact assessment tool poses a number of questions that aim to help assess and prioritise the identified vulnerabilities. This is achieved by bringing in (internal or external) specialist knowledge in a focused and systematic way.

D. Adaptation Strategy

An adaptation strategy expresses the present and the desired future position of a company in relation to climate change impacts. It also helps to communicate a company's attitude towards climate change internally and externally. To support this process, the tool lists key issues in relation to climate change strategy and provides an example of a policy statement.

E. Options Appraisal and Decision-Making

This part of the toolkit aides decision-making management options by providing a simple template for options appraisal.

F. Action plan

Here, short guidance on developing and implementing an action plan is given.

G. Integration Strategy

While a dedicated process is necessary to first identify the key climate issues, the objective must be to integrate climate change issues into the routine process of the organisation. While the types of procedures climate change should be integrated in will vary from company to company, the toolkit makes a number of suggestions as to how to integrate climate change considerations into business analysis, strategic planning, quality management, operational procedures and contingency planning.

4. Policy implications

We know about climate change as a result of scientific research, funded and promoted over many years by governments. The impacts of climate change will affect whole societies and regions, and government programmes have been at the forefront of assessing these impacts and devising possible responses. Many of the benefits of adaptation are likely to be collective and societal. But governments have only a limited capacity to implement adaptive measures and behaviours. Most adaptations will be put into practice by companies, households and individuals. Government therefore has a role in informing, encouraging, creating incentives and occasionally regulating private sector actors to adapt, while remaining cautious not to impose a single model on all organisations and people. Governments do not have unique foresight or wisdom with respect to the uncertain and highly-specific impacts of climate change.

One way of characterising the role of Government is that it should be to help actors to learn how to adapt, while showing some leadership in changing its own attitudes and actions. The UK Government's current role has been to fund research to understand climate change, through UKCIP to give advice and guidance, and to begin to assess risks for Government departments. Great emphasis is placed on having a stakeholder-driven process. However, there may be scope for an enhanced role for Government and policy, including the mainstreaming of climate adaptation in planning and in infrastructure development, funding research on adaptation measures, and through encouraging a diverse set of approaches to adaptation.

Government also has a role in preventing adaptive behaviours and processes leading to a shift of risks and costs to the weakest actors. To give a simple example, insurance companies may adapt to climate impacts by withdrawing cover to homeowners in areas of increased flood risk. These people will be both the most vulnerable to this specific impact, and may also have the least adaptive capacity – given that their ability to relocate will be related to their ability to sell their currently uninsurable homes. Here however Government faces a dilemma since it will not want to give incentives to ignore the risks associated with location in high flood risk areas. A certain level of compensation may be justified, perhaps partly funded by the insurance industry, together with tougher planning restrictions of further development.

The general problem of risk sharing and shifting is especially acute in industries like housing in which those at the beginning of the supply chain (suppliers, developers, architects etc) determine future vulnerability of the housing stock, while those at the

end of the chain (owners, occupiers, insurers, mortgage lenders etc) are more exposed to the risks. This mismatch in incentive structures could lead to insufficient levels of adaptation, or build-in rigidities that make future adaptation more costly and difficult. Policy can bridge the gap, sometimes through new regulation (such as building standards), while the financial sector (insurers and lenders) can also play a role in promoting early adaptation as a means of protection against risk.

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7. Publications and other dissemination activities

The articles and reports attached to this report are starred.

Refereed journal articles

Hertin, J., Berkhout, F., Gann, D.M., Barlow, J., 2003. Climate change and UK housebuilding: perceptions, impacts and adaptive capacity. *Building Research and Information* 31 (3-4 May-August), 278-290.*

Articles in preparation

Berkhout, F., Hertin, J., Gann, D., 2003, Learning to adapt: Organisational adaptation to climate change impacts (for submission to *Climatic Change*, January 2004).*

Berkhout, F., Hertin, J., 2003. Observing adaptation from the ground up: concepts and methods (for submission to *Global Environmental Change*, January 2004).

Arnell, N.W. and Delaney, K., 2003. Adapting to climate change: water supply in England and Wales (for submission to *Climatic Change*, 2004).*

Other publications

Berkhout, F., Hertin, J., Gann, D., 2003. Learning to adapt: A conceptual framework for organisational adaptation to climate change impacts. ADAPT project working paper. SPRU / Tyndall Centre for Climate Change Research, Brighton.

Berkhout, F. 2003. How can business adapt to climate change? Conference Summary, SPRU, University of Sussex, Brighton. July.*

Hertin, J., Haum, R., Berkhout, F., 2003. Toolkit for business adaptation to climate change. Fourth Report of the study: 'Climate Change: Developing a decision-making support framework for the Yorkshire and Humber region.'. SPRU, University of Sussex, Brighton.*

Haum, R., Hertin, J., Berkhout, F., 2002. Second progress report: Towards the development of an adaptation management tool for business. ADAPT Study. SPRU/Tyndall Centre for Climate Change Research, University of Sussex, Brighton. 15 November.*

Hertin, J., Berkhout, F., Delaney, K., Arnell, N., 2002. Business and climate change: Measuring and enhancing adaptive capacity. Progress report: Preliminary results from the house building and water sector. SPRU/Tyndall Centre for Climate Change Research, University of Sussex, Brighton. 18 April.*

Berkhout, F., 2002. A conceptual framework for adaptive capacity. ADAPT Project Note, SPRU. Brighton.

Hertin, J., Berkhout, F., 2001. How can business adapt to climate change? *The Edge*, ESRC, April 2001 (6), 2.

Contribution to several Tyndall Centre publications (e.g. *The Effect*, *TyndAll*)

Other dissemination activities

Conferences

Berkhout, F. 2003. Learning to adapt: findings of the ADAPT study. Paper to How can businesses adapt to climate change? conference, London, 16 June 2003

Berkhout, F., Hertin, J., Gann, D., 2003. Learning to adapt: organisational adaptation to climate change impacts. Paper to Adaptive Research on Governance in Climate Change (ARGCC) conference, Ohio State University, 31 October 2003

Presentations:

Tyndall/DTI presentation, DTI, April 2001 (Frans Berkhout)

Tyndall Assembly, 27 September 2001 (Frans Berkhout)

SPRU seminar, 9 October 2001 (Frans Berkhout)

UMIST seminar, Manchester, 19 November 2001 (Frans Berkhout)

Tyndall workshop, Cambridge 5 February 2002 (Julia Hertin)

IPCC Task Group on Climate Impact Assessment workshop, Amsterdam, 9 January 2003 (Frans Berkhout)

Tyndall Adaptation workshop, 30 January 2003 (Frans Berkhout)

London Climate Change Partnership, London, 13 February 2003 (Frans Berkhout)

BRASS/City Planning Department, University of Cardiff, 26 November 2003 (Frans Berkhout)

Business Partner and Advisory Panel meetings/workshops:

First Advisory Panel meeting: 18 December 2001

Second Advisory Panel meeting: 26 November 2002

First Business Partner workshop: 26 June 2001

Second Business Partner workshop: 10 June 2002

ADAPT Newsletter

June 2001 and February 2002

Other

Briefing DEFRA official in advance of minister's speech (May 2003)

8. Business Partners

Water

Anglian Water Services

Mid Kent Water

South East Water

Wessex Water

House building

Peabody Trust

St George Regeneration

Gleeson Homes

CDHA/Hyde Housing

Wilcon Homes

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The inter-disciplinary Tyndall Centre for Climate Change Research undertakes integrated research into the long-term consequences of climate change for society and into the development of sustainable responses that governments, business-leaders and decision-makers can evaluate and implement. Achieving these objectives brings together UK climate scientists, social scientists, engineers and economists in a unique collaborative research effort.

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The Tyndall Centre is named after the 19th century UK scientist John Tyndall, who was the first to prove the Earth's natural greenhouse effect and suggested that slight changes in atmospheric composition could bring about climate variations. In addition, he was committed to improving the quality of science education and knowledge.

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Recent Tyndall Centre Technical Reports

Tyndall Centre Technical Reports are available online at
http://www.tyndall.ac.uk/publications/tech_reports/tech_reports.shtml

Warren, R. (2002). **A blueprint for integrated assessment of climate change**, Tyndall Centre Technical Report 1.

Gough, C., Shackley, S., Cannell, M.G.R. (2002). **Evaluating the options for carbon sequestration**, Tyndall Centre Technical Report 2.

Köhler, J.H. (2002). **Modelling technological change**, Tyndall Centre Technical Report 3.

Goodess, C.M. Osborn, T. J. and Hulme, M. (2003) **The identification and evaluation of suitable scenario development methods for the estimation of future probabilities of extreme weather events**, Tyndall Centre Technical Report 4.

Stemmers, K. (2003) **Establishing research directions in sustainable building design**. Tyndall Centre Technical Report 5.

Macmillan, S. and Köhler, J.H., (2004) **Modelling energy use in the global building stock: a pilot survey to identify available data**, Tyndall Centre Technical Report 6.

Adger W. N., Brooks, N., Kelly, M., Bentham, S. and Eriksen, S. (2004) **New indicators of vulnerability and adaptive capacity**, Tyndall Centre Technical Report 7.

Skinner, I., Fergusson, M., Kröger, K., Kelly, C. and Bristow, A. (2004) **Critical Issues in Decarbonising Transport**, Tyndall Centre Technical Report 8

Gill, J., Watkinson, A. and Côté, I (2004). **Linking sea level rise, coastal biodiversity and economic activity in Caribbean island states: towards the development of a coastal island simulator**, Tyndall Centre Technical Report 9.

M. N. Tsimplis (2004). **Towards a vulnerability assessment for the UK coastline**, Tyndall Centre Technical Report 10.

Berkhout, F., Hertin, J. and Arnell, N. (2004). **Business and Climate Change: Measuring and Enhancing Adaptive Capacity**, Tyndall Centre Technical Report 11.