OECD publishing

Please cite this papers as:

Agrawala, S. et al. (2011), "Private Sector Engagement in Adaptation to Climate Change: Approaches to Managing Climate Risks", OECD Environment Working Papers, No. 39, OECD Publishing.
http://dx.doi.org/10.1787/5kg221jkf1g7-en

OECD Environment Working Papers
No. 39

Private Sector Engagement in Adaptation to Climate Change

Shardul Agrawala, Maëlis Carraro, Nicholas Kingsmill, Elisa Lanzi, Michael Mullan, Guillaume Prudent-Richard

OECD

Unclassified **ENV/WKP(2011)9**

Organisation de Coopération et de Développement Économiques
Organisation for Economic Co-operation and Development **18-Feb-2013**

English - Or. English

ENVIRONMENT DIRECTORATE

ENV/WKP(2011)9
Unclassified

Cancels & replaces the same document of 30 November 2011

ENVIRONMENT WORKING PAPER N°39

PRIVATE SECTOR ENGAGEMENT IN ADAPTATION TO CLIMATE CHANGE: APPROACHES TO MANAGING CLIMATE RISKS

S. Agrawala (1), M. Carraro (1), N. Kingsmill (1), E. Lanzi (1), M. Mullan (1) and G. Prudent-Richard (2)

(1) OECD
(2) AECOM, Australia

JEL Classification: Q54, Q58, M19
Keywords: Adaptation, Private Sector, Climate Change, Risk Management

All OECD Environment working papers are available at www.oecd.org/environment/workingpapers

JT03334807

Complete document available on OLIS in its original format
This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

English - Or. English

OECD ENVIRONMENT WORKING PAPERS

This series is designed to make available to a wider readership selected studies on environmental issues prepared for use within the OECD. Authorship is usually collective, but principal authors are named.

The papers are generally available only in their original language English or French with a summary in the other if available.

The opinions expressed in these papers are the sole responsibility of the author(s) and do not necessarily reflect those of the OECD or the governments of its member countries.

Comment on the series is welcome, and should be sent to either env.contact@oecd.org or the Environment Directorate, 2 rue André Pascal, 75775 PARIS CEDEX 16, France.

OECD Environment Working Papers are published on
www.oecd.org/env/workingpapers

Applications for permission to reproduce or translate all or part of this material should be made to: OECD Publishing, rights@oecd.org or by fax 33 1 45 24 99 30.

Copyright OECD 2011

ABSTRACT

There is growing international interest in the planning, financing and implementation of adaptation to climate change. However, the discussion to date has primarily focused on the public sector's role, with the private sector viewed primarily as a source of funding or financing. Relatively little attention has been paid to how the private sector is responding to the risks and opportunities from climate change. In this context, this analysis aims to contribute to a deeper understanding of private sector's role.

This paper examines the private sector's progress in adapting to climate change by considering information from sixteen case studies, drawn from a range of industries across the private sector. This is complemented by a high-level analysis of broader private sector adaptation based on responses to the 2009 Carbon Disclosure Project questionnaire. The case studies provide insight into companies' awareness of potential climate risks and vulnerabilities, their progress in assessing specific impacts on their businesses and possible ways to respond to them, and their implementation of adaptation measures and strategies to manage these risks. The analysis also examines how companies are taking advantage of new business opportunities arising from climate change.

The paper explores companies' motivations for implementing adaptation measures, and establishes common factors which can affect companies' capacities to adapt, their incentives for action, and their perspectives on the need to adapt. The analysis considers how these factors can both encourage and impede adaptation, and assesses potential public sector roles for eliminating barriers to action, encouraging engagement and incentivising private sector investment in adaptation.

JEL Classification: Q54, Q58, M19

Keywords: Adaptation, Private Sector, Climate Change, Risk Management

RÉSUMÉ

La planification, le financement et la mise en œuvre des politiques d'adaptation au changement climatique font l'objet d'un intérêt croissant à l'échelle planétaire. Cependant, le débat reste encore essentiellement cantonné au rôle du secteur public, le secteur privé étant surtout considéré comme une source de financement. Une attention relativement faible est donc accordée à la façon dont le secteur privé réagit aux risques et opportunités liés au changement climatique. Dans ce contexte, la présente analyse entend contribuer à mieux faire comprendre le rôle du secteur privé.

Le présent document examine les progrès du secteur privé dans l'adaptation au changement climatique en analysant les informations de seize études de cas couvrant diverses industries du secteur privé. Il est complété par une analyse de haut niveau de l'adaptation du secteur privé dans une optique plus large. Cette analyse se fonde sur les résultats du questionnaire 2009 du Carbon Disclosure Project. Les études de cas informent sur le degré de sensibilisation des entreprises aux risques potentiels du changement climatique et aux vulnérabilités qui peuvent en découler, ainsi que sur les progrès de ces entreprises dans l'évaluation des impacts sur leur activité spécifique et des moyens d'y faire face. Elles fournissent également des informations sur la mise en œuvre par ces entreprises de mesures et de stratégies d'adaptation pour contrer ces risques. L'analyse examine par ailleurs la façon dont les entreprises saisissent les opportunités d'activités nouvelles créées par le changement climatique.

Le présent document examine les motivations des entreprises à mettre en place des mesures d'adaptation et il expose les facteurs communs aux entreprises et susceptibles d'affecter leur capacité d'adaptation, leurs initiatives d'action et leurs perspectives sur la nécessité de l'adaptation. L'analyse envisage également la façon dont ces facteurs peuvent à la fois favoriser et ralentir l'adaptation. Enfin, elle évalue les rôles que pourrait assumer le secteur public pour faire tomber les obstacles à l'action, encourager l'implication et promouvoir les investissements du secteur privé dans l'adaptation.

Classification JEL: Q54, Q58, M19

Mots-clé : adaptation, secteur privé, changement climatique, gestion des risques

FOREWORD

This report on "Private Sector Engagement in Adaptation to Climate Change: Approaches to Managing Climate Risks" has been overseen by the Working Party on Climate, Investment and Development (WPCID).

This working paper has been authored by Shardul Agrawala, Maëlis Carraro, Nicholas Kingsmill, Elisa Lanzi, Michael Mullan and Guillaume Prudent-Richard. In addition to WPCID delegates, the authors would like to thank Jan Corfee-Morlot, Chris Kennedy, Nicolina Lamhauge, Raynald Macher-Poitras, Victoria Schreitter and Marie-Christine Tremblay of the OECD and Markus Sainsbury of AECOM for their valuable input and feedback, and Hanni Rosenbaum of the Business and Industry Advisory Committee to the OECD for her assistance. The authors would also like to thank all companies who participated in this study for their important contributions, and in particular are grateful to Monika Baer (BASF), Jean-Yves Caneill (EDF), Brent Dorsey (Entergy), Joel Gailhard (EDF), Xavier Guizot (Carrefour Group), Richenda Hall (BG Group), Achim Ilzhöfer (Bayer), Samir Jazouli (Veolia), Helen Keep (Unilever), Yves Kersuzan (Etudes et Projets Industriels), Sue Lacey (Rio Tinto) ,Lit Ping Low (PricewaterhouseCoopers), Philippe Meunier (GDF SUEZ), Andrew Parsons (AngloGold Ashanti), Erik Pharabod (Réseau de Transport d'Electricité), David Quincey (Anglian Water) and Jen Tweddell (Shell) for their involvement.

This document does not necessarily represent the views of either the OECD or its member countries. It is published under the responsibility of the authors.

Financial support from the US Environmental Protection Agency (EPA) is gratefully acknowledged.

This paper is released as part of the OECD Environment Working Papers series [ENV/WKP(2011)9]. It can be downloaded on the OECD website: www.oecd.org/env/workingpapers or www.oecd.org/env/cc/adaptation.

Further enquiries on ongoing work on Adaptation to Climate Change should be directed to Michael Mullan, OECD Environment Directorate (Email: Michael.Mullan@oecd.org; Tel: +33 1 45 24 13 17)

TABLE OF CONTENTS

ABSTRACT ... 3
RÉSUMÉ ... 4
FOREWORD ... 5
ACRONYMS ... 8
EXECUTIVE SUMMARY ... 9
1. INTRODUCTION ... 11
2. THE PRIVATE SECTOR AND CLIMATE CHANGE: BACKGROUND AND METHODOLOGY ... 13
2.1. Climate change risks to businesses ... 13
2.2. Interpreting private sector adaptation responses ... 15
2.3. Methodology for analysing adaptation in the private sector ... 17
3. PRIVATE SECTOR ENGAGEMENT IN ADAPTATION ... 19
3.1. Risk awareness ... 19
3.2. Risk assessment ... 21
3.2.1. Assessment of current and short-term climate change risks ... 22
3.2.2. Assessment of long-term climate change risks ... 24
3.2.3. Assessment of possible adaptation options ... 26
3.3. Risk management ... 28
3.3.1. Decision not to implement adaptation measures ... 29
3.3.2. “No regret” and soft adaptation measures ... 29
3.3.3. Hard adaptation measures ... 33
3.4. Harnessing opportunities ... 36
3.5. Common trends and factors affecting engagement ... 40
3.5.1. Capacities ... 42
3.5.2. Incentives ... 43
3.5.3. Perspectives ... 44
4. CONCLUSION ... 45
REFERENCES ... 47
ANNEX 1: BUSINESS SECTORS AND SUB-SECTORS ... 53
ANNEX 2: COMPANIES INTERVIEWED FOR THE ANALYSIS ... 54
ANNEX 3: ADDITIONAL ADAPTATION EXAMPLES ... 55

Tables

Table 1. Potential sectoral climate change risks 15
Table 2. Possible adaptation strategies..... 16

Figures

Figure 1. Illustrative framework of business components and possible climate change impacts 14
Figure 2. Three tier adaptation framework..... 17
Figure 3. Risk Awareness Summary 21
Figure 4. Risk Assessment Summary..... 28
Figure 5. Risk Management Summary..... 36

Boxes

Box 1. Entergy's "Operation: storm ready" 24
Box 2. RTE's EcoWatt initiative..... 33
Box 3. A meta-analysis of Carbon Disclosure Project 2009 (CDP7) questionnaire responses..... 41

ACRONYMS

BAAC	Bank for Agriculture and Agricultural Co-operatives (Thailand)
CDP	Carbon Disclosure Project
CIMMYT	International Maize and Wheat Improvement Centre
CSR	Corporate social responsibility
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEFRA	Department for Environment, Food and Rural Affairs (UK)
DTMA	Drought Tolerant Maize for Africa
EPI	Etudes et Projets Industriels
ERDF	Électricité Réseau Distribution France
GIS	Geographic information system
IMFREX	Impact des changements anthropiques sur la fréquence des phénomènes extrêmes de vent de température et de précipitations
IP	Intellectual property
IPCC	Intergovernmental Panel on Climate Change
JBIC	Japan Bank for International Co-operation
NAPAs	National Adaptation Plans of Action
OECD	Organisation for Economic Co-operation and Development
Ofwat	The Water Services Regulation Authority (UK)
PPP	Public private partnership
PwC	PricewaterhouseCoopers
R&D	Research and development
RTE	Réseau de Transport d'Electricité
SIPPEREC	Syndicat Intercommunal de la Périphérie de Paris pour l'Électricité de les Réseaux de Communication
UNEP	United Nations Environment Programme

EXECUTIVE SUMMARY

Adaptation to climate change is now widely recognised as an equally important and complementary response to greenhouse gas mitigation. Understanding the private sector's role in adaptation is crucial, as countries' success at adaptation will depend on the success of the private sector and other private actors in responding to climate change impacts and risks. Additionally, private sector responses may provide lessons and examples of innovative approaches of interest to the public sector.

Significant national and international discussion is currently ongoing regarding the planning, financing and implementation of adaptation. However, to date, this has focused on the public sector, with discussion of the private sector tending to focus on its potential as a funding source for adaptation action. This analysis aims to contribute to a wider understanding of private sector activities by analysing: what motivates private actors to undertake adaptation; the factors that determine processes of adaptation; and the role of government in enabling and incentivising the private sector to take action.

Climate change will present businesses with a range of risks, which may significantly affect their business operations, their competitiveness, and their profits. Given that businesses face these risks, the rational self-interest of businesses should be a major driver of adaptation actions. To consider how companies are responding to these changes, this analysis draws on information obtained through 16 case studies of companies active on adaptation issues, as well as public information, supporting literature and an analysis of responses to the 2009 Carbon Disclosure Project (CDP) questionnaire. A three tier analytical framework has been used to assess companies' engagement in adaptation: risk awareness; risk assessment; and risk management. The analysis also considers whether companies are taking advantage of the wide range of new and additional business opportunities arising from climate change.

There is a high level of awareness among companies of the broad range of risks posed by climate change – all companies interviewed for the case studies were aware of potential risks, though not all perceived their businesses were vulnerable to them. Companies focused more on risks from extreme events than on those from gradual changes. However, not all companies carry out assessments of risks or of possible adaptation responses. This observation is supported by the analysis of CDP responses – three quarters of CDP respondents acknowledged climate change risks, but only two fifths of these companies also conduct risk assessments. Most companies assessed risks from current climate variability and extreme events, but fewer also assessed risks from future climate change. Only a third of companies assessed possible adaptation options. Assessments are generally more concerned with direct impacts and often focus on increases in frequency and intensity of extreme events. Some companies use existing systems for assessments, such as incorporating climate change into risk management processes. Others adapt existing tools or develop new tools for considering climate risk. Some companies do not possess the in-house capacity to conduct assessments, especially of future risks, and may utilise external expertise.

However, the case studies indicated a gap between risk assessments and the implementation of risk management actions. This is also reflected in CDP analysis – only one fifth of respondents that assess risk also implement actions to manage them. The majority of companies interviewed decided not to implement hard adaptation measures, such as investments in infrastructure. Companies may not implement such measures as some feel they are already taking necessary actions to address climate change, or that supply chain flexibility limits the need for specific anticipatory actions. Others have implemented "no regret" or

soft measures, which are synergistic measures that are also beneficial to general business operations, or which address current climate or environmental concerns. Soft measures, such as addressing water scarcity or supply issues, allow companies to react flexibly to climate change while limiting the risk of potentially unnecessary investments in adaptation measures. One third of interviewed companies have implemented hard measures, such as infrastructure investments. Hard measures are particularly relevant for companies which are more vulnerable to climate change impacts, which have restricted operational flexibility and which rely on fixed assets. The main examples of such actions came from regulated utilities companies, which rely on long-term fixed assets, and may be better able to finance adaptation investments as they can pass costs of adaptation on to customers more easily than other companies. The analysis also indicates that many companies are aware of possible opportunities arising from climate change, such as consulting services, water management services and technologies, and climate-proofing construction services.

However, this analysis has found that the visible level of activity may understate the actual level of activity. Actions to improve the management of climate risks may occur as part of standard risk management or planning processes without being explicitly labelled as adaptation. There is little incentive for companies to identify and publicise the work they are doing on adaptation. Many of the benefits are private and the messages sometimes complex, which give it less potential as a source of positive publicity than action on mitigation. In addition, information on adaptation can be a source of competitive advantage. Indeed, companies interviewed were often cautious about sharing details of their adaptation actions.

There are several factors that can encourage or hinder companies' levels of adaptation action. These factors can affect companies' capacities to adapt, their incentives for action, and their perspectives towards the need to adapt. In some cases, decisions not to adapt and factors which inhibit adaptation may be rational responses to companies' operating contexts. However, in other cases governments may be able to use approaches, tools and policies to encourage adaptation and help companies overcome barriers.

- **Capacities:** Companies' *ability to finance adaptation* can affect their engagement, as they can be deterred from incurring upfront expenses even when the overall balance of costs and benefits is positive. The *presence of in-house capacity and expertise* in companies can enable them to assess risks and implement adaptation more easily. The *presence of a climate research and development (R&D) infrastructure* and *private sector partnerships with the public sector, scientific organisations and academia* can facilitate decision making and encourage adaptation.

- **Incentives -** *Uncertainty of climate impacts* can limit companies' incentives to invest in adaptation measures. *Flexibility in production* can reduce the need for pre-emptive measures, as companies may be able to adjust production or supply sources, while inflexibility in operations or locations increases the incentive to invest in adaptation measures. *Policy and regulatory environments* can stimulate private sector engagement by encouraging or requiring adaptation. Some companies' *business planning horizons* may be too short to consider long-term climate change impacts, which may reduce their incentives to implement adaptation.

- **Perspectives –** Companies with *previous negative experiences of natural disasters or extreme climate conditions* or *previous experience of managing climate sensitivities* may be more likely to adapt if they have prior experience of the potential costs of climate change and of how to manage environmental risks. The *framing of opportunities versus risks* can also affect engagement, as companies may invest more readily when climate change presents opportunities rather than costs.

The results suggest three areas for future analysis: the economic case for adaptation (whether observed adaptation levels match the efficient level, and the costs and benefits of early versus delayed responses); whether companies' responses to current climate variability help or hinder their responses to future climate change; and the interplay between public and private sector adaptation strategies.

1. INTRODUCTION

Adaptation to climate change is now widely recognised as an equally important and complementary response to greenhouse gas mitigation. Significant national and international discussion is currently ongoing regarding the planning, financing, and implementation of adaptation. On a parallel track there has been considerable expansion of policy and economic analyses to assess adaptation costs and benefits and the cost-effectiveness of adaptation actions. The core emphasis of both research and financing, however, has been on activities that are primarily financed and implemented by public entities.

In comparison, much less attention has been paid to the role of the private sector in fostering adaptation. However, countries' success in adaptation depends heavily upon the decisions made within the private sector. It is therefore important to understand how the private sector is responding to the threats and opportunities arising from climate change. This understanding can help inform the development of policy frameworks that are conducive to adaptation, identify if there are currently barriers to action and share lessons learnt.

Businesses are increasingly aware of the need to respond to climate change, both in operational and strategic terms. Climate change will have a range of impacts on businesses, including disrupting business operations, increasing costs of maintenance and materials, and raising insurance prices. In other cases, climate change may also offer new business opportunities. Pressure for private sector engagement also comes from increasing consumer demand for environmentally friendly products and governmental attempts to regulate environmental externalities. In this context, preparing for the effects of climate change will become increasingly important as companies seek to maintain their current operations and competitive advantage. While understanding the current and potential role of the private sector in adapting to climate change is important, it is also crucial to identify the tools and policies that can be used to encourage their engagement.

The literature on the private sector and adaptation to climate change is relatively recent and so far there has been limited analysis of actual adaptation. Research has primarily been devoted to setting up the discussion and making the case for private sector action in adaptation (Acclimatise, 2009a; Long, Zadek and Wickerham, 2009; Pew Center on Global Climate Change, 2008; WBCSD, 2008; PwC, 2010). A few early movers have undertaken sectoral analyses outlining business recommendations for adaptation. Among these, notable work has focused on cross-sectoral analyses rating the risks of climate change by business sector (KPMG, 2008; NBS, 2009). Others have assessed specific industries such as the mining industry, the oil and gas sector, and power utilities (David Suzuki Foundation, 2009; Acclimatise, 2009b, 2009c, 2010), ports and financial institutions (IFC, 2011, 2010a) the energy production and transmission sectors in the United States (CCSP, 2007) and Australia (Parsons Brinckerhoff, 2009), and the building and water sector in the UK (Berkhout, Hertin and Arnell., 2004). Studies have also considered methods for businesses to assess risks (IFC, 2010b) businesses' attitudes towards adaptation (Ipsos MORI, 2010) and general climate change trends in relation to private sector adaptation, such as water scarcity (Ceres, 2009).

In an effort to gain a better understanding of private sector adaptation, this analysis considers the principal risks that businesses are likely to face due to climate change, the actions they have taken to address these risks, and how they are managing current climate variability and adapting to future climate conditions. This assessment also addresses the questions of:

- What motivates private actors to undertake adaptation actions?
- What factors determine processes of adaptation?
- What is the role of government in enabling and encouraging the private sector to take action on adaptation to climate change?

Businesses' attitudes towards adaptation and the actions taken to address risks arising from climate change are analysed using a three-tier framework that considers companies' actions in terms of their: (1) risk awareness; (2) risk assessment; and (3) risk management. Additionally, a wide range of new business opportunities are expected to arise due to climate change. The analysis therefore also considers how companies are taking advantage of these evolving opportunities.

This analysis considers case studies based on information collected from a number of companies across a range of different sectors and industries. The information obtained from these case studies is supplemented with publicly available information, supporting literature, and an analysis of companies' responses to the Carbon Disclosure Project (CDP) 2009 questionnaire on business responses to climate change. These sources are used to consider the private sector's engagement in adaptation, common factors and incentives which can both encourage and inhibit engagement, and examples of instances where governments have acted to promote and support adaptation. These common factors and examples may offer a starting point for future research concerning how governments and regulators can encourage private sector engagement in adaptation to climate change.

2. THE PRIVATE SECTOR AND CLIMATE CHANGE: BACKGROUND AND METHODOLOGY

The private sector is likely to face significant risks as a result of climate change – Section 2.1 considers key risks and vulnerabilities faced by businesses, and how these can vary across sectors, sub-sectors and industries. Section 2.2 discusses the private sector's initial adaptation responses to climate change. Section 2.3 sets out the methodology and framework for assessment used in this analysis.

2.1. Climate change risks to businesses

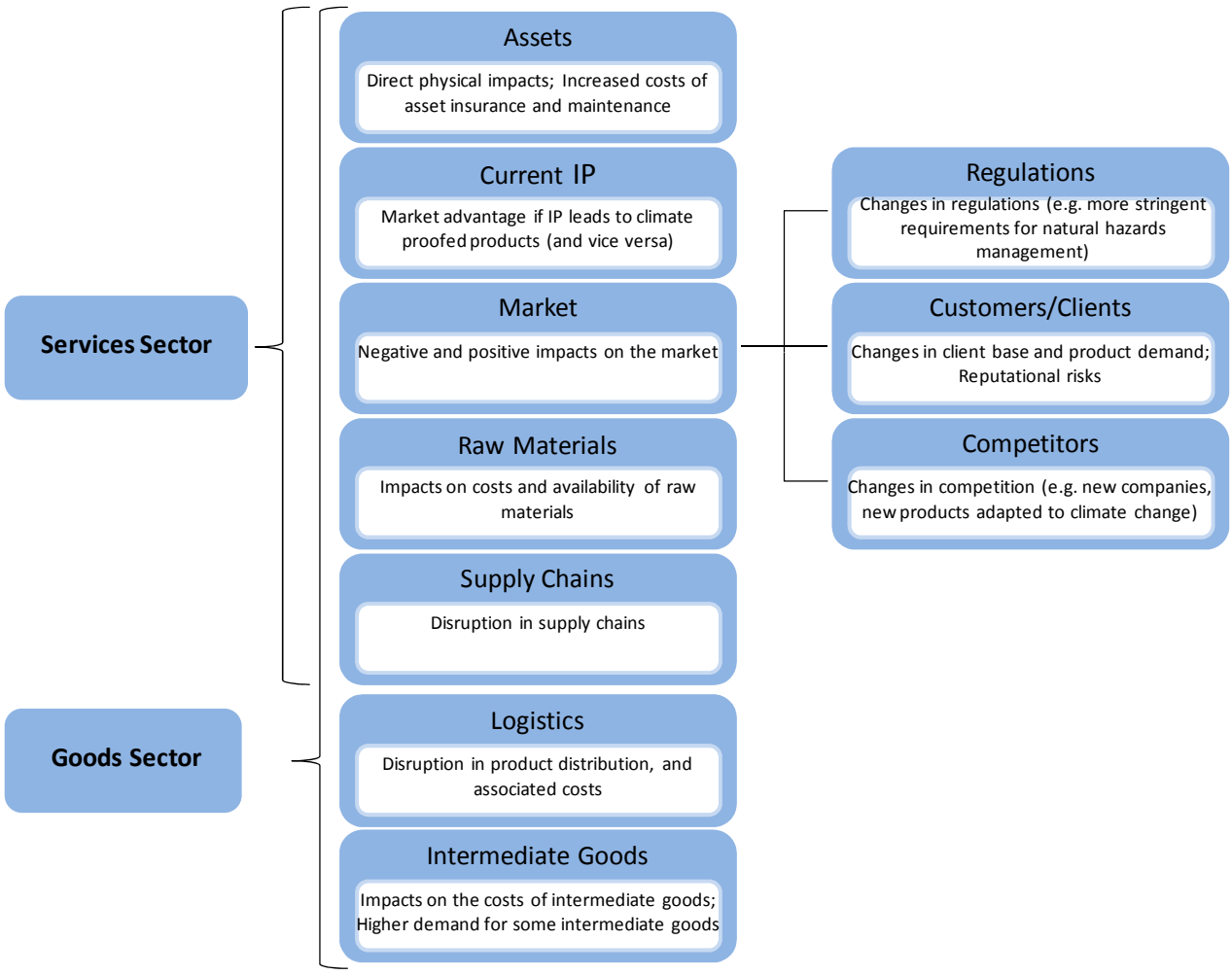
Much of the recent attention to adaptation has focused on the role of the public sector. However, existing research on public sector adaptation may not be applicable to the private sector due to differences between the groups: the public sector is affected by different sets of incentives to the private sector, and may also face different risks. For the purpose of this analysis, the private sector is defined as privately owned or controlled companies, organisations and entities, whereas the public sector is the part of the economy owned or controlled by the public, usually through public agencies. This definition of the private sector therefore does not include other private actors, such as individuals or households.

Within the private sector there are a wide range of possible business structures, ranging from individual traders to multi-national corporations. Therefore, even within the private sector climate change risks to and impacts on different companies will vary. Additionally, climate change will affect companies in many different ways: it can affect the ways businesses operate, impact the profitability of their operations, and create opportunities. Businesses may be exposed to different risks as a consequence of climate change, including systemic risks across the entire economy and specific risks at the sector, industry and company levels (Hoffman and Woody, 2008). These risks can be both direct and indirect, and include: physical risks, supply chain and raw material risks, reputational risks, financial risks, product demand risks, regulatory risks, and litigation risks.

Companies' exposure to these risks will vary depending on their business operations and on the sector in which they operate. This paper broadly categorises businesses as operating in three sectors – the goods sector (in which companies produce tangible items such as commodities, minerals or merchandise), the services sector (in which companies provide intangible products such as accounting, banking or education), and the joint goods and services sector (in which companies provide both goods and services, or rely on assets or raw materials to deliver services).

Figure 1 provides an illustrative framework of potential channels by which climate change can affect companies. All companies depend on a range of operational components, though companies operating in different sectors are concerned with different sets of components – businesses in the goods sector typically have additional concerns to those in the services sector. However, as indicated in Figure 1, climate change can impact on all operational components involved in delivering both goods and services, and can therefore have serious repercussions for all businesses.

Figure 1. Illustrative framework of business components and possible climate change impacts



Businesses also face specific challenges depending on the industry in which they function. Within the three main sectors, further industry sub-sectors can be identified. This sectoral breakdown helps to identify specific risks faced by different sectors and industries – the sector businesses operate in and the types of goods and/or services that they provide can directly affect their exposure to climate change risks. Impacts may be felt more keenly in certain sectors, while others may be relatively immune to climate change risks. Table 1 illustrates the breakdown of sub-sectors used in this analysis, and provides examples of potential risks faced by different industries.[1]

[1] The breakdown of sectors is based the North American Industry Classification System (NAICS) – the European Union equivalent is the Nomenclature des Activités Économiques dans la Communauté Européenne (NACE). See Annex 1 for a description of the individual sub-sector areas.

Table 1. Potential sectoral climate change risks

Goods producing sectors	**Manufacturers**	**Physical risks** – Disruption to operations due to extreme weather events; Damage to infrastructure; Restrictions to production due to rising temperature, variations in water quality and in water availability
	Agriculture and mining businesses	**Physical risks** – Extreme weather events increase physical risks to business operations; Risk of overflow of storage due to increased rainfall; Resource extraction could be limited by sea level and water availability **Supply chain and raw material risks** – Water scarcity affects production **Product demand risks** – Changes in quality, quantity and type of agricultural products **Logistics risks** - Risks to the transport corridors and transport hubs from where raw materials are processed and exported
Goods and services providing sectors	**Retailers and distributors**	**Physical risks** – Damage to products during transportation due to extreme events **Supply chain and raw material risks** – Interruption, inefficiency or delays in supply chain; Difficulties with water scarcity and increased fuel prices **Reputational risks** – Decrease in product quality affecting reputation and consumers' satisfaction
	Transportation	**Physical risks** – Extreme weather events causing delays, supply disruptions and losses of goods; Access to transport routes affected by flooding, permafrost thawing and mass movements, subsidence due to drought
	Utilities	**Physical risks** –- Disruptions of supply due to flooding or extreme events; Business interruption due to extreme weather **Supply chain and raw materials risks** – Reduced output due to water scarcity impacting hydropower and power plants using a thermal plant cooling system **Product demand risks** – Demand effects due to temperature changes **Regulatory risks** – Increasing pressure to conserve water in water scarce areas
Services providing sectors	**Financial businesses**	**Financial risks** – Risks in investment portfolio where investments are made in areas with climate vulnerabilities; Increased risk of customer default
	Information businesses	**Physical risks** –- Disruptions of operations due to extreme weather events; Difficulties in transportation
	Real estate businesses	**Physical risks** –- Delays and disruptions in construction projects; Damage to buildings and drainage problems; Additional costs due to temperature changes increasing cooling loads **Regulatory risks** – Changes in building and design requirements **Financial risks** – Loss of value due to climate change impacts
	Other service businesses	**Product demand risks** – Tourism industry affected in its infrastructure and by changes in tourism demands caused by different climatic conditions

In addition to these risks and vulnerabilities, the private sector will also face new and additional opportunities as a result of climate change. As with the risks and vulnerabilities businesses face, the availability and extent of these opportunities will vary depending on the sectors and industries in which businesses operate.

2.2. Interpreting private sector adaptation responses

One of the defining characteristics of adaptation is that the benefits are often local and private. Self-interest should be a powerful driver for companies to manage their exposure to risks and exploit opportunities. Economic theory suggests that this will lead them to adopt cost-effective adaptation strategies. However, there is only scattered evidence so far that companies are taking action on adaptation. For example, Ipsos MORI (2010) contacted a range of UK businesses and only 23% of those surveyed reported having taken action in response to the risks of climate change.

The first challenge in interpreting this is that companies' may not label their actions as adaptation. Actions to improve businesses' resilience or to manage environmental or climate risks may occur as part of standard risk management or planning processes, and may not be explicitly categorised as an adaptation response to climate change. The second challenge is that there are weak drivers for companies to publicise their actions on adaptation. Because the benefits of adaptation are often local and private, and therefore

usually only benefit the company itself, adaptation does not fit neatly within standard Corporate Social Responsibility (CSR) narratives. This can make it harder for companies to effectively communicate how they are adapting to climate change. This contrasts with mitigation actions, such as greenhouse gas reduction goals or carbon offset policies, which have global and public benefits to society and are therefore easier to communicate as part of standard CSR strategies. Additionally, information regarding companies' climate vulnerabilities may be sensitive, because it could indicate potential weaknesses to competitors or negatively affect competitiveness or market valuations, so companies may not publicise the climate risks they face or the actions they have taken to manage these risks. Furthermore, if adaptation actions provide a competitive advantage, there is a disincentive for companies to share that knowledge more widely. These factors suggest that the degree of visible or publicised action may be a poor indicator of the extent of actual action.

The third challenge in interpreting the amount of visible action is to do with the nature of adaptation. The effects of climate change are long-term, uncertain and context-specific. Frameworks for decision-making under uncertainty have suggested that it can be rational to delay significant and irreversible investments (Ranger *et al.*, 2010).Secondly, it is difficult to draw broad conclusions about what companies ought to do be doing, because the appropriate risk management strategy will depend upon their particular circumstance. Lastly, some adaptation responses are open to different interpretations. This can be seen from the classification of generic adaptation responses. For example, tolerating losses can be part of an efficient adaptation strategy or it can be the result of companies failing to consider climate change.

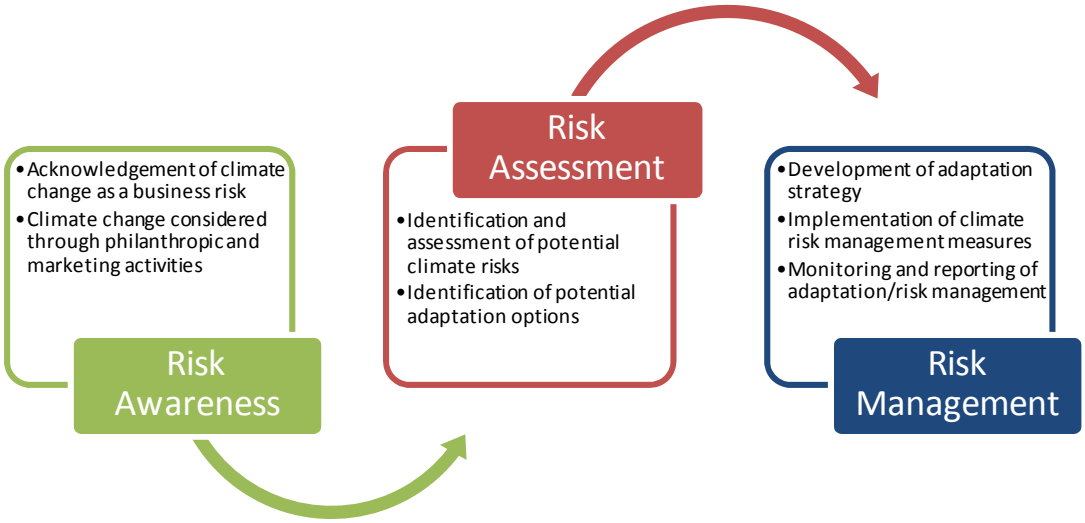
Table 2. Possible adaptation strategies

Adaptation Strategy	Description
Preventing losses	Take action to reduce the exposure to climate impacts
Tolerating losses	Accept losses where it is not possible or cost effective to avoid them
Spreading or sharing losses	Distribute the burden of impacts through insurance
Changing use or activity	Switch of activity or resource use to one better suited to climate change
Changing location	Move operations to an area that is more suitable
Restoration	Restore assets to their original condition following damage

Source: Adapted from Burton, 1996

To understand and interpret how the private sector is adapting to climate change, this analysis uses a three tier framework that considers: (1) risk awareness, (2) risk assessment and (3) risk management. Risk awareness is the starting point for private sector considerations of climate change, and indicates that a given company is aware that climate change could affect their business. This can lead them to undertake a risk assessment that moves from a general awareness towards a specific understanding of the risks and opportunities for their business and operations. Depending on the results of this risk assessment process, they may decide that it is necessary to implement explicit risk management strategies. Each successive level builds on the results of the preceding one. Awareness if a prerequisite for action and risk assessment is needed to determine the appropriate risk management:

Figure 2. Three tier adaptation framework



It is important to note that the policy debates about how to separate out the effects of current climate from the additional impacts of climate change are of less relevance to companies. The key question for them is what their risks are now and how these will evolve over time. As such, action that is in effect adaptation may not be viewed as such by the company in question. This paper has adopted a broad perspective, in that it includes as adaptation measures that have been taken in relation to existing climate extremes which additionally improve companies' resilience to climate change, and measures that have either been identified by the respondents as relating to climate change, or to circumstances that have been made worse by climate change.

2.3. Methodology for analysing adaptation in the private sector

This analysis has compiled case studies for a number of companies across different sectors to shed light on the level of action currently underway, and to help clarify what is driving their adaptation actions. Information on companies' adaptation experiences has been obtained by directly contacting 16 companies (see Annex 2 for a full list of companies). Based on companies' responses to the 2009 CDP questionnaire, companies which were particularly active on climate issues were identified and requested to participate in this analysis. Following this initial selection, additional companies were identified and approached with the assistance of the OECD Business and Industry Advisory Committee (BIAC). The final set of companies included in the analysis was determined to some extent by the availability of the respondents. The companies considered in this analysis are therefore not a representative sample – they are a relatively small selection of private sector companies, and may be more engaged in climate change issues and adaptation than the broader private sector. Caution must therefore be exercised in drawing broad conclusions based on this sample of companies.

However, the selection of companies considered in this analysis is not intended to provide a comprehensive sample of all private sector response, but to provide an overview of key issues relating to adaptation. Focusing on those companies which are more active in responding to climate change allows for a better analysis of the factors that motivate action and provides a richer dataset for considering companies' experiences in assessing risks and implementing adaptation. Additionally, the selection of companies represents a varied subset of the private sector and allows for analysis of key issues across a many different areas of the private sector. The companies considered operate across a range of industries within the goods, services, and goods and services sectors. The companies undertake a broad range of activities, including scientific and technological production, mining, food and non-food retailing, water

services, energy services, and financial services. Companies are based in a range of countries and have headquarters in Australia, France, Germany, the Netherlands, South Africa, the United Kingdom and the United States. Many of the companies operate globally, with offices, operating locations or product reach across the globe. The analysis also includes companies that operate locally within a single country or region. This varied sample of companies allows the analysis to identify both issues that may be unique to specific contexts and broad themes common across businesses. While the companies interviewed are primarily based in developed countries, the transnational operations and reach of many of the companies means that much of the analysis is directly relevant to developing country and emerging economy contexts. Furthermore, the discussion of motives for undertaking adaptation and of the role of government in incentivising adaptation is not specific to any national context, and is applicable to developed, developing and emerging economies.

Information was collected from companies via email or through telephone or face-to-face interviews. Companies were asked to explain their activities in awareness, assessment and management of climate change risks. The level of detail in the companies' responses varied and depended on their activities as well as their ability to disclose information. Where available, publicly accessible information, such as that available on companies' websites, was used to complement directly provided information. Additional analysis and further examples of private sector engagement in adaptation have also been drawn from publicly available information, and from supporting literature. The analysis has paid particular attention to companies' motivations for engagement in adaptation, as well as to any opportunities that they foresee arising due to climate change. Additionally, the analysis includes an examination of survey responses to the 2009 CDP questionnaire. This provides broad, high-level information about general private sector response to climate change, which complements the in depth information on companies motivations and actions provided by the case study analysis.

3. PRIVATE SECTOR ENGAGEMENT IN ADAPTATION

The case study analysis of companies' engagement in adaptation indicates that all interviewed companies are aware of possible climate change risks, and almost all carry out assessments of current climate risks. However, fewer assess future risks or adaptation options. A few companies do not feel the need to implement adaptation actions, but the majority implement "no regrets" or soft adaptation measures. Half of these companies also implement hard adaptation measures. Based on companies' adaptation experiences, this analysis has identified a range of factors that can encourage or discourage action on adaptation.

This analysis is primarily based on the information provided by interviewed companies. However, as discussed in Section 2.2, there were limits to the information that companies were able to share publicly. There were sensitivities about publicising detailed information on their climate change strategies and information about financial implications. As a result, this section focuses on providing an overview of companies' motives for action and the factors that affect their adaptation processes and decisions, rather than providing a detailed account of their actions. The results discussed in this section are based on the analysis of case study interviews and supporting information – the results of the meta-analysis of CDP questionnaire responses are presented separately in Box 3.

3.1. Risk awareness

All companies interviewed stated that climate change can pose significant risks, though two companies did not believe their specific operations to be subject to climate risks. Almost all companies had a good knowledge of the possible impacts of climate change on the economy and had specific knowledge of the impacts that are relevant for their business operations. Companies pay particular attention to physical risks and risks to supply chains and raw materials, and are generally also aware of product demand risks and financial risks. Some companies recognised the impact that certain regulations could have on their businesses in the presence of climate change or in the event of extreme weather events. However, it was less clear how aware companies are of potential reputational and litigation risks to their businesses.

Companies are aware of both changes in the pattern of extreme weather events and gradual changes, but tend to focus more on extreme events. However, there were some exceptions: for example, energy companies are concerned about gradual changes in temperature levels as they influence the demand for energy.

The level of awareness of potential impacts of climate change on companies and their operations varies greatly. Based on the collected information, different aspects of awareness of climate change can be identified:

- Recognition of climate change risks;
- Engagement in national dialogues or international negotiations;
- Internal training to raise awareness of climate change impacts;
- Conducting awareness-raising campaigns.

While most companies recognise current and future risks that climate change may pose to their operations, fewer engage in supplementary activities relating to awareness. Four companies engage in national or international climate change dialogues, three companies carry out internal training, and two companies conduct awareness-raising campaigns. However, many companies publicise their engagement in addressing climate change risks, although they provide varying levels of detail regarding their adaptation strategies. For example, the French energy company EDF publicises on its website that it has established a strategy for adaptation to climate change. This strategy addresses the evaluation of climate change on EDF's activities, the necessary adaptation actions, the integration of future climate change adaptation in the design of new installations, and the improvement of the climate resilience of existing plants (EDF, n.d.). A quarter of interviewed companies have engaged in national or international dialogues around climate change, such as national adaptation planning projects. Where climate can be a hazard for a company's activities and operations, training to increase awareness of climate change impacts and risks may be implemented – a fifth of the companies interviewed stated that they have engaged in training exercises or schemes.

Companies may use their websites to demonstrate their awareness of climate change and engage in awareness-raising exercises: they illustrate climate change issues, highlight their initiatives to address them, and in some cases publicise the results of their awareness-raising campaigns. For instance, the chemical and pharmaceutical company Bayer has developed initiatives to raise awareness of climate change impacts among children: they publish a children's book "What's up with the Earth: The mystery of early spring"; they support education in climate change affected regions (for example, they support the CSIRO CarbonKids educational programme in Australia); and they co-organise the "International Children's Painting Competition on the Environment" with the United Nations Environment Programme (UNEP) (Bayer, 2010a, 2010b).

Engaging in and publicising training schemes and awareness raising campaigns can be a way for companies to illustrate their engagement in climate change issues and their awareness of risks, and may form part of wider CSR initiatives. However, these schemes may also form part of companies risk management strategies. For example, training may be intended to prepare employees to take action in the event of a disaster, and awareness-raising campaigns may attempt to influence public or customer behaviour.

The motivations behind companies' different awareness levels vary. Some companies are aware of climate change impacts because they have previously encountered losses due to adverse climatic events. For example, Entergy, Réseau de Transport d'Electricité (RTE) and EDF's engagement in adaptation was catalyzed by their experiences of extreme events. In other cases companies are motivated by the possibility of seizing opportunities that can arise due to climate change, such providing climate change consulting services. Companies' levels of engagement at the national and international level also appears to depend on the level of engagement of the public sector in national climate change dialogues and the public attention given to adaptation to climate change. Thus, government plays an important role in promoting private

sector engagement in adaptation. Companies may be influenced by and follow approaches or guidelines suggested by national adaptation strategies or National Adaptation Plans of Action (NAPAs).[2]

Private sector initiatives to raise climate awareness may also draw on input and assistance from international organisations and partnerships. For example, the UNEP Finance Initiative Climate Change Working Group has coordinated several financial organisations to promote their engagement in adaptation to climate change. For example, in an effort to understand the climate information requirements of the financial sector as part of their and their customers' adaptation strategies, UNEP Finance Initiative and the German Sustainable Business Institute surveyed sixty financial institutions on their information needs (UNEP FI, 2011).

Figure 3. Risk Awareness Summary

Risk Awareness

- Companies are aware of the broad range of climate change risks, and pay particular attention to physical risks and risks to supply chains and raw materials.
- Companies focus more on *extreme weather events* than on *gradual changes* (except in specific industries, such as the energy sector)
- Levels of awareness vary - all companies interviewed *recognise risks*, a quarter engage in *national or international dialogues*, and a few carry out *internal training* or engage in *awareness-raising campaigns*.
- Motivations for engagement in climate change vary, with companies involved due to previous losses due to climatic events, due to national engagement or guidelines for considering adaptation, and due to the desire to seize new opportunities.
- Partnerships with international organisations can help encourage private sector engagement in climate change and adaptation.

3.2. Risk assessment

Assessing the risks of climate change can be a challenging task. Careful assessments of such risks are perceived to be costly and require additional capacity that companies do not always have. Additionally, climate change impacts are inherently uncertain and the tools for dealing with this uncertainty can require a high degree of technical sophistication. Whether climate change risks pose a threat to companies' operations depends on several factors, including the nature of the climatic phenomenon, the economic sector considered, the business operation concerned, and the primary input factors the company relies on (Lash and Wellington, 2007). Furthermore, different business sectors are not equally vulnerable to climate change, and climate change will also present business opportunities to some sectors.

[2] NAPAs provide a process for Least Developed Countries to identify priority activities that respond to their urgent and immediate needs to adapt to climate change. NAPAs list and prioritise adaptation activities and projects and provide profiles of each activity or project (UNFCCC, 2002)

While both extreme weather events and incremental changes are of concern, companies often focus on possible increases in the frequency and intensity of extreme events. This analysis found that interviewed companies were generally more concerned about direct effects of climate change such as damage to company assets and infrastructure, interruption of operations and business continuity, or damage to products due to extreme events, weather-related disasters or floods. Companies appeared to be less concerned about the possible indirect and compound impacts which may affect company business models (Acclimatise *et al.*, 2009). Key indirect risks for companies include: the decline of raw material availability used for production; increased costs of transport to reach suppliers; increased incidence of diseases affecting employees' ability to work; shifts in consumers demand that require company to modify or entirely drop a product line. Of such indirect risks, supply chain risks are one of the main concerns for companies, as they could have repercussions on the overall business operations.

Participants in the case studies followed a variety of approaches to risk assessment. Two thirds of companies assessed climate risks using their own tools and frameworks, such as Environmental Management Systems or existing risk management frameworks. This leads to very different levels of risk assessments – some may be detailed and use up to date climatic modelling information, while others may not prioritise climate change risks to a degree that would require them to be considered in risk assessment and planning processes. Some companies addressed climate change alongside other business risks – three of the companies interviewed broadened the scope of their existing risk management procedures to integrate emerging climate change risks into their overall risk assessment process. However, from a company perspective, climate change remains only one factor that influences decision making among many others, and is often considered as one of many lenses through which to view risk (KPMG, 2008).

The incorporation of climate risks may require that companies consider longer time frames than those traditionally used in risk assessments. However, not all companies consider long-term time frames – only half of those which assess current and short-term climate risks also assess long-term risks. Those companies which do consider long-term climate change risks use varying timescales, ranging from 10 to 50 years. However, even these longer timescales are short relative to the timescales of climate projections. In addition to considering risks, a third of companies indicated that they explicitly assess possible adaptation responses.

3.2.1. Assessment of current and short-term climate change risks

The main focus of interviewed companies' short-term risk assessments was on the direct and immediate impacts associated with current climate vulnerability. More systemic risks were less likely to be included on the basis that they were perceived as distant and uncertain. On the other hand, more frequent and violent natural hazards may already be evident, and in some cases have prompted companies to look at climate change issues more thoroughly.

Some companies included climate change within their broader assessments of environmental risks. For example, Carrefour's risk assessment considers climate change and natural disasters alongside a range of other environmental risks. These assessments of 'Natural Risk' include a forward-looking component evaluating the impact of climate change. Such assessments are articulated in three levels:

- **Risk mapping** – The company maps the areas and specific locations where risks might occur. Carrefour uses a geographic information system (GIS) to map the risks for each region where the group operates.

- **Risk Prevention** – The company implements local measures to mitigate any identified risks.

- **Crisis management** – The company develops a business continuity plan for the identified risks.

Risk assessments are conducted for all countries where Carrefour operates. At the macro level, Carrefour's 'Country Risk' assessment corresponds to a cumulative assessment of all external risks and threats capable of disrupting the Carrefour Group's economic activity temporarily or structurally, endangering the security and safety of its employees, or tarnishing the Group's image, reputation or credit rating in a given country. Specific situations in each country are examined according to nine themes (politics, health, economics, terrorism, natural disasters, labour, infrastructure, criminality and CSR) using regularly updated stable references, which are crosschecked against expert opinions. At the micro level, it focuses on direct damages and operating losses at specific branches or operational groups. Each risk is ranked in a one to five scale, according to the intensity and importance of the risks for the company. This assessment has a one- to five-year timeline and is used as an input to the five-year strategic plan. Carrefour's assessments consider already existing uncertainties in food supplies caused by weather variability, and it considers that, except for natural disaster risks in the medium-term, climate change does not currently pose any additional risks.

However, other companies may regard the increased variability of weather conditions due to climate change as a significant risk. These companies focus particularly on extreme weather events, including storms and heavy rain, and on extreme temperature events. Several examples of consideration of variability of climate conditions can be found in the utilities sectors, where climate can affect the supply of services to customers and negatively affect companies' production. For example, variability of temperatures can affect water availability and thus water supply and energy production, and extreme climate events can affect supply operations.

Companies that have been affected by climate events in the past often monitor climate variability in order to reduce their vulnerability to future events. This is the case for the Entergy Corporation, an integrated energy company engaged primarily in electric power production and retail distribution operations, which suffered considerable losses due to Hurricane Katrina in 2005. Following the hurricane the company decided to take action to assess the risks of increasing extreme events as a consequence of climate change and strengthen its power distribution network. In 2006, Entergy founded a business continuity group to identify the drivers of risk in the Gulf Coast Region it serves.

One of the primary concerns for Entergy is the increasing occurrence of violent hurricanes. In 2009, the company commissioned external consultants to analyse the energy and economic impacts of hurricanes on the Gulf Coast energy infrastructure. The study produced a high level assessment of the costs of impacts, risks for customers located in unsafe areas, and risks for transmission, distribution and generation infrastructure.

Entergy also recognises significant risks in terms of supply disruption. In order to limit energy supply problems, the company has set up continuous monitoring and forecasting of climate variability to be able continually assess current weather conditions and to quickly react to extreme weather events. In particular, it has set up a programme for preparedness to storms (see Box 1). This monitoring and assessment of current weather variability shows that the company not only assesses current climate risks but that such assessments have been incorporated in their business planning and operating activities.

Box 1. Entergy's "Operation: storm ready"

Entergy's storm preparation mechanism is a continuous cycle based on training, monitoring, mobilising human resources and acting to reduce weather damages, as well as collaborating and learning from these experiences. This project is aimed at quickly responding to weather-related supply disruptions, and at restoring and safely reconnecting customer power supplies.

Different programmes exist in the various states where the company operates (Arkansas, Louisiana, Mississippi, New Orleans and Texas). Monitoring climate variability and threatening weather that could possibly affect customers is fundamental for the success of the programme. Entergy monitors climate variability using "the latest high-tech tools and services" to track dangerous weather systems (Entergy, 2011).

Source : www.entergy.com

Other interviewed companies whose activities are subject to climate variability also monitor weather and climate forecasts. For these companies, climate change is exacerbating the problem of climate variability that has previously posed business risks. The existence of such risks has led to strong collaborations between weather forecasting companies and utilities firms. For instance, energy utilities in France, such as EDF or RTE, collaborate closely with the French weather forecast agency Météo-France in order to stay updated on weather conditions.

Companies with a particularly strong engagement in weather monitoring also used external weather forecast and climate models to formulate their own short- and long-term forecasts. For example, RTE, the company responsible for high and very high voltage electricity transmission in France, develops seasonal forecasts evaluating both demand for and supply of electricity, which strongly depend on temperature and on hydrological, solar and wind conditions. On this basis, RTE analyses security of supply issues that could arise due to particular climate conditions. An example is their forecast analysis for summer 2011 in which they consider events such as heat waves, assessing their probability and their likely impacts on the energy network (RTE, 2011). EDF also develops short-term seasonal forecasts, studying the consequences that the forecast weather would have on energy production. An example is the use of the modelling techniques for considering water flow forecast and snowmelt contribution to energy production in the French mountain areas (Garçon, 1996; Andreassian *et al.*, 2006; Paquet, 2004).

3.2.2. Assessment of long-term climate change risks

Assessments of future climate risks go beyond several interviewed companies' usual planning timeframes. Additionally, the uncertainties around future climate change impacts and the delays until impacts are felt are disincentives for companies to produce detailed assessments, as they may see climate impacts as issues that can be dealt with in the future. This response may be rational if future impacts will not be overly severe or if adaptation can be implemented at short notice, but this may only be known if assessments are undertaken.

Conducting assessments of long-term climate risks can be difficult as they can require specialised skills in the use of scenarios and projections. Companies that do not have the capabilities to develop models and conduct in-house assessments may base their assessments on IPCC projections or commission studies from external consultants. Three of the companies interviewed indicated that they contracted external consultants to produce part or all of their assessments of long-term risks. For example, the first step of the strategy for addressing adaptation by the mining and resources group Rio Tinto included a study of an IPCC assessment report, and an analysis of the impacts of climate events on their business and of the areas of their operations exposed to risk.

In 2008, AngloGold Ashanti, a South African mining company with global operations, commissioned external consultants to identify and, where possible, quantify the company's climate change-related risks. The study reviewed a number of key climate risks and challenges the company will face, as well as possible responses. Risk assessments were conducted for each region where the company operates. The assessment analysed the physical impacts of climate change, considering both impacts on the company's operations (e.g. disruptions of activities, employee health, safety and well-being) and impacts on surrounding communities (e.g. food security, disease and sustainable development). The analysis considered predicted future climate change impacts, current climatic, geographical and environmental conditions, as well as existing climate change vulnerabilities and adaptive capacity for each of the company's operating locations.

The study found that AngloGold Ashanti's operations are exposed to a number of direct physical risks from climate change. This is partly due to the fact that AngloGold Ashanti's existing operations are already located in environments characterised by water stress, high temperatures, and flood and landslide risk, with these conditions set to be exacerbated due to climate change. The study assessed the key expected climate change impacts for each operating location, and the key operational risks that will stem from them. Such risks include: exacerbated risks of flooding and landslides; negative impacts on infrastructure due to increases in wet conditions and rainfall intensity; increased temperature impacts on employee well being; and increased energy consumption for ventilation and cooling.

AngloGold Ashanti also assessed the risks faced by the surrounding communities in the countries where they operate as climate change impacts could cause human distress for the affected populations and could also significantly affect company operations. Detailed physical risk assessments were conducted for all communities at risk from climate change in regions where AngloGold Ashanti operates. The communities were found to be exposed to several impacts of climate change.

In addition to considering current and short-term risks, Entergy has also considered long-term climate change impacts – in 2010 Entergy released a report, commissioned from external consultants, discussing future climate change impacts in the US Gulf Coast area. The report quantified future climate risks in the region and presented options that could help to address these risks (Entergy, 2010). The study addressed uncertainty in climate change impacts by considering three different climate change scenarios – representing no, average and extreme climate change – and the variation in impacts under the different scenarios. The study also modelled natural hazards, such as hurricanes, using probabilistic analysis (i.e., considering event frequencies and severities). The modelling was validated through a comparison of historical and simulated data to produce a robust and reliable projection of exposure to cyclones in the Gulf Coast.

The study concluded that the Gulf Coast is currently vulnerable to growing environmental risks. More specifically, the Gulf Coast faced an annual expected loss of around USD 14 billion in 2010, and this loss was forecast to increase by 50-65% by 2030. Approximately half of this estimated loss is driven by climate change impacts, namely increased hurricane damages and sea level rises, but it is also driven by economic growth (which would make the economic impact of a hurricane event worse in the future) and by land subsidence. It was projected that the Gulf Coast region could accrue more than USD 350 billion in direct cumulative economic damages by 2030. Total direct and indirect impacts could increase the estimated cumulative costs to more than USD 700 billion over the period from 2010 to 2030.

Four of the seven companies which consider long-term impacts have developed in-house resources for the assessment of future climate change risks. Since 2002, Rio Tinto has been investigating the long term impact of climate change on operations and major projects (Mills, 2009). Their attention to climate change developed as a consequence of the losses encountered due to extreme weather events. Rio Tinto has used external climate modelling expertise to develop climate projections through to 2060. While most global

climate models use a grid size of about 300 km^2, this high resolution modelling uses a grid size as small as 20 km^2, and covers four geographical "windows" of interest. This high resolution allows modellers to capture small scale influences that characterise climate variables in key regions, and provides Rio Tinto businesses with climate projections that can be used to assess future climate risks (Mills, 2009). This modelling was conducted externally, but was used as an input to internal risk assessment processes. For example, this information has been used to assess risks associated with sea level rise at a smelter project site at Sarawak, on the north Borneo coast of Malaysia.

Companies may also collaborate with research centres or public sector institutes, which can offer support in areas where companies lack expertise and can assist companies' adaptation processes. One example is EDF's involvement in the IMFREX (Impact des changements anthropiques sur la fréquence des phénomènes extrêmes de vent de température et de précipitations) project, developed in collaboration with Météo-France and other scientific research partners (IMFREX, 2005). Each of these partners has different competencies in areas ranging from building characteristics, to climate modelling or geographical physics.

The IMFREX project aims to evaluate the impacts of climate change on the frequency of extreme wind, temperature and precipitation events in France. Temperature changes are modelled using a model developed by Météo-France, and additional models are then used to project the frequency and intensity of tropical cyclones, extreme temperature events, wind-climate relationships, and the impact on snow patterns. This last impact is modelled using a methodology developed by EDF's research and development (R&D) department.

Similarly, Rio Tinto Alcan's involvement with the Ouranos consortium (the Consortium on Regional Climatology and Adaptation to Climate Change) in Quebec provides a model for collaborative research to assist companies' adaptation processes. The consortium, which has established a network of 250 scientists and researchers from different disciplines and institutions, aims to integrate climate science and societal adaptation requirements in order to help society adapt to climate change. The consortium is conducting integrated research projects, including regional climate modelling, and assessments of the physical and human impacts of climate change and possible adaptation responses (Ouranos, n.d.). Rio Tinto Alcan, a Quebec-based subsidiary of Rio Tinto, joined the Ouranos consortium as an affiliated member in 2010 (Ouranos, 2010). Rio Tinto Alcan has committed USD 500 000 to a research partnership with the consortium, and aims to use outputs from Ouranos research to improve their short- and long-term hydrological forecasting (Rio Tinto Alcan, 2010).

3.2.3. Assessment of possible adaptation options

While many interviewed companies assess the possible impacts on climate change on their operations, fewer assessed possible options for managing climate risks. Five of the companies interviewed stated that they assess adaptation options.

Anglian Water, a water and sewerage services company which operates in East Anglia, the driest region in the UK, face a number of challenges due to climate change and have undertaken an assessment of the risks to their current operations. This has allowed them to identify both procedural and operational adaptation priorities across the company, which are being used to inform both their short- and long-term planning. Examples include (Anglian Water, 2009):

- **Now** – Manage the impact of current and future flooding and other weather-related incidents by increasing operational resilience.

- **Short- to Medium-Term** – Manage seasonal changes in climate by improving network resilience and managing the supply/demand balance through water metering, water efficiency programmes and leakage control.

- **Long-Term** – Ensure current and future assets are designed to be resilient to the impacts of climate change for the next 40 years and beyond.

Before adaptation actions are selected, those identified are subject to a cost/benefit analysis to assess their appropriateness. Funding for any actions selected is then requested from the regulator for construction in the appropriate five year regulator period (the next submission will be for 2015 to 2020). Short term actions include optimising and protecting existing assets, whereas, for the medium- and long-term, it is probable that greater investment will be required for process change or infrastructure development.

Veolia, an environmental services company which carries out water supply and management, waste management, energy, and transport operations, has also assessed adaptation options. Veolia Water, a subsidiary of Veolia, is working on solutions to enable municipal and industrial clients to adapt to climate change and has identified various types of solutions to re-establish the balance between demand and supply when there are threats or shortages. In its 2007 Sustainable Development Report, Veolia proposed various adaptation options, including measures to address water scarcity such as the use of water reservoirs, recharging of groundwater and wet zones, and rainwater storage (Veolia Environnement, 2007).

In their 2011 report to the UK Department for Environment, Food and Rural Affairs (DEFRA), in response to a direction to report under the Climate Change Act 2008, Veolia (2011) assessed potential adaptation responses for its operations in the southeast of England. These include:

- **Education** – provision of information to customers to encourage efficient use of water.

- **Water tariffs** – new methods of charging water to be tested between 2010 and 2015;

- **Metering** – increase coverage to 96% of supply region from its current level of 90%.

- **Water efficiency operations** – continuous adaptation, support for tighter building regulations.

- **Efficient management of supply** – promotion of demand management and water efficiency activity, and efficient management of existing resources.

Figure 4. Risk Assessment Summary

Risk Assessment

- Risk assessments vary based on companies' capabilities and priorities – some countries use dedicated tools to assess climate risks while others broaden the scope of existing risk management procedures to include climate change.
- The incorporation of longer time frames into risk assessments to capture long-term climate change risks is not yet common.
- The possible increase in frequency and intensity of *extreme events* is often the main focus of risk assessments, and companies are generally more concerned about direct impacts than about indirect impacts.
- Almost all interviewed companies assess *current and short-term climate change risks*. Many focus on direct and immediate impacts that may already be evident, such as more frequent and violent natural hazards, rather than more distant and uncertain systemic risks. Previous experience of climate events can be a driver for undertaking assessments.
- Fewer companies assess *future climate change risks* – half of the companies interviewed assess longer-term impacts. As companies may not possess the capability or capacity to conduct these assessments themselves, they are sometimes based on IPCC projections or commissioned from external consultants.
- Assessments of *adaptation options* are difficult as they need to be based on detailed identifications of impacts at local levels – less than a third of interviewed companies carried out such assessments.

3.3. Risk management

Although private sector assessments of possible climate change impacts and adaptation options shows a high level of engagement in some aspects of adaptation, there is a gap between assessment and implementation of adaptation actions.

This analysis differentiates between soft and "no regret" adaptation measures and hard adaptation measures that are decisions on large-scale planning and investments with high irreversibility. "No regret" measures are usually beneficial to the firms under all plausible future climate change scenarios. Soft adaptation measures include commercial changes in products and services, strategic changes such as relocating facilities, diversifying the supplier base, outsourcing production across many facilities, providing additional storage facilities in flood affected areas, or financial strategies to protect the business. Hard measures include specific technological and infrastructural changes involving capital goods that consider specific climate change risks in planning and design. The selection of specific measures will depend on the extent and type of changes that the company has to make in order to be climate proofed. Most of the identified measures allow for a large degree of flexibility – this is seen as a strategic issue for companies as it allows them to respond to market stimuli in a timely fashion.

Companies' engagement in implementing risk management measures varies. Having assessed climate change impacts on their business operations, some companies may decide not to implement adaptation measures, or to delay implementation. This can be part of an efficient adaptation strategy if the expected benefits of those measures are outweighed by the costs. Other companies have implemented "no regret" activities that can be classified as adaptation, but which they would have implemented in any case for other purposes. Companies may also implement other soft adaptation measures, such as adding flexibility to their production procedures and operations or incorporating climate change in risk management processes. Finally, firms may go beyond "no regret" and soft measures and implement hard adaptation measures, such as investments in infrastructures.

3.3.1. Decision not to implement adaptation measures

Three of the interviewed companies feel that they are already taking the necessary actions to tackle the risks of climate change impacts. For example, based on currently available climate models, the chemical company BASF does not currently see the need to pursue adaptation measures within the next ten years beyond the non-adaptation risk management actions it has already taken. Given the pace of climate change, they believe that necessary adaptation investments have already been carried out and that adaptation will happen gradually, partly within the framework of regular investment cycles. Specifically, BASF has already installed additional water pumps at one of its operating sites to ensure that even at low water levels sufficient water from the River Rhine is available for production, and has converted cooling systems at some plants from water cooling to air cooling. These adaptations will enable BASF operations to continue even in low water conditions, without the need to implement specific adaptation measures.

Similarly, having assessed climate change risks, Carrefour has decided that they do not need to implement adaptation actions at present. Carrefour thoroughly assessed climate change impacts as part of the company's risk assessment. The company believes that its activities have not been significantly affected by extreme weather events, changes in weather patterns, rising temperatures or sea level rise. Although such phenomena have an impact on agricultural activities and the supply of agricultural products, their impacts are generally location-specific and Carrefour is already accustomed to the quality and quantity of fresh food supplies being impacted by climatic conditions.

Based on risk assessments, these companies have made conscious decisions to not implement adaptation measures. This illustrates that these companies pay attention to climate change issues and that they consider possible risks, at least in the short term. If in the future climate change appears likely to further impact them, their awareness and assessment of climate change impacts means that they should be capable of detecting such risks and of implementing adaptation measures at that time.

3.3.2. "No regret" and soft adaptation measures

The majority of implemented adaptation actions are either "no-regret" or soft measures – two thirds of interviewed companies have implemented such measures. This aligns with the academic work that has been undertaken on decision-making in the presence of uncertainty, as discussed in Section 2.2. These measures usually deal with current climate variability and current environmental concerns, or are measures that are beneficial to the companies' business operations while also making them more resilient to climate change impacts. Examples of such synergistic measures can be found in several industry sectors and typically address issues of water scarcity, sustainable agriculture, the climate resilience of suppliers and sources of raw materials for production, and market-driven changes in customer demand.

Addressing water scarcity and supply issues

As water scarcity is a growing concern for businesses, many interviewed companies have initiated actions to minimise water consumption. In fact, in many cases the impacts of water scarcity and increased competition for available resources are already discernable. Companies across almost all industry sectors observe decreases in companies' water allocations, more stringent regulations, higher costs for water usage and increased public scrutiny of corporate water practices (Ceres, 2009). As climate change is likely to exacerbate these existing risks, companies see water scarcity as a key strategic challenge. Many initiatives have been launched to help businesses to identify risks and opportunities related to water use and their impacts, and to help them develop corporate water management plans. The most notable examples of such initiatives include the UN CEO Water Mandate, the Water Footprint Network and the World Business Council for Sustainable Development (WBCSD) Global Water Tool.

One business area that is particularly affected by water issues is mining. Rio Tinto has adopted several adaptation measures as part of its water strategy (Rio Tinto, n.d.). Water is used at all stages of the mining production process: exploration, mining, processing, smelting and refining. Additionally, Rio Tinto's industrial plants are often located in arid zones with problems of water scarcity and high competition for water with other users. Rio Tinto's water strategy aims at improving the company's efficiency in the use of water, and its exploitation of new knowledge and technology. Water use and quality control standards have been established to ensure good performance in the use of water resources. Each business operation also invests in designed water infrastructure, such as water storage and borefields. There are several examples of measures that can be considered as adaptation, including water recycling, the reuse of water from a tailings dam, the use of technologies to minimise evaporative water losses, and efforts to raise awareness on water conservation issues among communities, employees and contractors.

Water utilities companies are also adapting to water supply problems. The British water utility Severn Trent's adaptation strategy focuses on water resource management and planning in order to ensure a continuous supply of water. In particular, after a flooding incident in 2007 Severn Trent recognised the need to increase the resilience of its sites and services (Severn Trent Water, 2009). Severn Trent has included addressing climate change impacts in 25 year strategic plan, and is investing GBP 1 000 million over the period from 2010 to 2015 in order to safeguard service provision to its customers (Severn Trent Water, 2011). This investment plan includes increasing the resilience of Severn Trent's network and water treatment works, reducing leakages, increasing water efficiency, and increasing protection against flooding. Veolia provides another example – the company is aiming to improve network resilience for its UK operations by reducing risks of leakage and investing in new technologies (Veolia Water South East, 2011).

Securing supply availability and promoting sustainable agriculture production

The food industry is beginning to implement measures to control risks of environmental changes, which can be synergistic with adaptation and may increase its resilience to climate change risks. The industry is particularly exposed to risk through its production of raw materials, especially in arid and semi-arid regions that are expected to become drier due to climate change impacts such as reduced rainfall and water runoff.

For example, Unilever, a consumer goods manufacturing company, has continued and extended its work on sustainable agriculture which it started more than a decade ago. As part of its Sustainable Living Plan, launched in 2010, the company has set a target to source 100% of its agricultural raw materials sustainably by 2020. By the end of 2010 the company sourced 10% of its total agricultural raw material purchases sustainably.

Unilever does not foresee significant disruption due to extreme events for its manufacturing base and operating sites, as its multiple manufacturing operations across the world allow the company enough flexibility to avoid disruptions in supply. Nevertheless, at a site level, Environmental Management Systems are in place to manage both energy and water consumption and to consider impacts of adverse climatic conditions, such as floods and droughts. The company has had a particular focus on water scarcity, looking at sites in areas of the world already experiencing water stress and those that are likely to become water stressed in future years. Some of these actions, in particular those related to water scarcity, can be classified as adaptation action as they are motivated by the need to address sensitivities to climate change impacts.

Unilever has developed the "Unilever Sustainable Agriculture Code" – a detailed guideline for agricultural best practice which is based on 11 indicators, including aspects such as water use, energy, soil fertility, use of agri-chemicals and animal welfare. This code ensures sustainable agricultural practices are in operation across the value chain for all crops including palm oil, soy, tea, cocoa and fruit & vegetables, for example tomatoes. Unilever aims to work collaboratively with its suppliers to reach its sustainable sourcing goals. Given the breadth of Unilever's supply chain, the company's work on sustainable sourcing extends across a range of countries and addresses a number of key issues, such as water conservation in China, the US and India and deforestation in Indonesia and Tanzania.

As the largest private buyer of Kenyan smallholder tea, Unilever's Lipton tea brand set up a public private partnership project in 2006 with the Kenya Tea Development Agency (KTDA) and other partners to train smallholder farmers in sustainable tea cultivation. The initial plan targeted 120 farmers to be trained through farmer field schools. In the event, due to its success, 720 farmers were trained. The field schools, based at four factories where farmers bring their tea for weighing and collection by the KTDA, offered a hands-on experience, encouraging farmers to talk about common problems, find their own solutions and devise field experiments to identify best practices for sustainability. The farmers received practical guidance accompanied by courses on book-keeping and health and safety. The three-year project, which concluded in December 2008 improved farmers' profitability and increased their tea yields by an average of 5-15%.

The tomatoes Unilever sources are produced under contract by farmers in areas including Europe, the US, India, Chile and China. Unilever works with its tomato growers in these countries to investigate a range of sustainable agriculture practices. The programmes have focused on improving soil fertility, water management and pest control and have found for example that using drip irrigation can halve water consumption while also improving yields and reducing fertiliser and pesticide use. In the United States Unilever is leading a multi-stakeholder group to develop a common metric for measuring water use in tomato irrigation and is working with specialists to develop water efficiency advice for farm irrigation. Unilever is encouraging farmers and processors to work together through the Processed Tomato Foundation to address issues such as water scarcity.

Responding to changes in consumer demand

Companies have also undertaken adaptive measures driven by likely changes in the demand for their products. This is the case for Malmesbury Syrups, a specialist food company which produces flavoured syrups, based in the UK. Malmesbury Syrups is a small company able to quickly develop new recipes and products. Having realised that the company's products were linked to cold weather and that temperature increases might dissipate the demand for such products, the company decided to offer new products designed to meet the demand of clients living in warmer temperatures, such as syrups used for milkshakes (SWCCIP, 2008).

Unilever is also considering the potential impacts of climate change on its consumers: the company is adapting its product portfolio to be fit for a future of more constrained resources. Consumers in some countries are already feeling the impacts with increased water scarcity and high water prices. To address these issues, Unilever has launched a fabric conditioner for hand-washing laundry which reduces the amount of water required to rinse detergent from clothes by two thirds. This saves an average of 30 litres of water per wash, often at a lower cost to consumers than traditional products while at the same time reducing the effort and time needed to hand-wash laundry. Unilever estimates that consumers could save 500 billion litres of water annually if this conditioner were used by all its laundry product users in Asia and South Africa.

Utility companies may face similar issues and difficulties, as the demand for energy and water is significantly affected by climatic conditions. Energy companies, such as EDF, have invested in weather forecasting so as to be able to organise their production facilities in such a way as to avoid disruptions even during high demand periods. For instance, weather forecasting can be used to anticipate heat waves that will lead to high use of energy for cooling purposes. In these circumstances, the programming of which generation plants to use for power production will be planned accordingly to meet changes in customer demand. This may be complicated by issues that arise on the production side. For example, at the same time as high temperatures cause lead to increased energy demands, water scarcity due to dry weather may cause the closure of certain hydroelectric plants, or high temperatures may limit the use of nuclear plants where the temperature of the water used for cooling is too high for ensuring compliance with the thermal regulation of rivers.

Utilities companies can adapt to changes in customer demand through the use of pricing measures to help manage consumer demand. In the context of water distribution, water metering and water pricing are both effective measures to help manage demand. Such measures have been in use for a long time, alongside alternative supply and demand management measures such as water efficiency programmes. However, in response to climate change companies are considering expanding their use. Anglian Water are implementing parallel water efficiency, leakage control and metering extension programmes. Between 2010 and 2015 they intend to increase water meter penetration from 66% to 80% of households, continuing the move away from fixed cost water charges which do not provide an economic incentive to moderate water use. At the same time they will audit water use and retrofit water efficiency devices at over 87 000 domestic premises and maintain the sustainable economic level of leakage from their network.

Companies have also used customer-focused awareness raising campaigns to control demand in critical climatic situations. In instances of high temperatures or lack of precipitation, demand control measures could help minimise the risks of water shortages. Similarly, energy supply disruptions are more common in cold weather situations. Controlling energy demand can help avoid overloading power transmission networks and resultant power cuts. For example, in response to the particular risk of power cuts during cold weather peaks in the Brittany region, RTE has developed an awareness raising initiative aimed at limiting energy demand through encouraging behavioural changes among customers (see Box 2). This initiative has now been extended and is also operating in the Riviera region in the south-east of France.

Box 2. RTE's EcoWatt initiative

The Brittany region of France produces only 8% of the electricity it uses. It therefore needs to be supplied with additional energy, which primarily stems from power plants located some distance away. As a result the local network is subject to heavy loads, especially during peak periods in winter, which increases the risk of power cuts in a number of departments in the area.

While long-term solutions are being considered, including developments to generating facilities and transmission infrastructures, management of energy demand is important during critical periods in order to avoid power cuts.

To help achieve more manageable energy demands, RTE has developed the EcoWatt in Brittany initiative, which aims to raise awareness about the importance of power system balance and encourage consumers to adapt their energy use at times of peak demand. The initiative includes a website with information on the energy supply in the region and on how to save energy, and a voluntary alerting mechanism that sends notifications to customers via email or SMS. In collaboration with the EcoWatt project, the French mail company, La Poste, has also agreed to issue information and display appeals in its Brittany offices. An evaluation of the EcoWatt program indicated that most participants modified their energy usage in response to EcoWatt alerts, and that they passed on alert information to others (RTE, 2009).

Source : www.ecowatt-bretagne.fr

3.3.3. Hard adaptation measures

While many of the interviewed companies implement "no regret" or soft actions, fewer take further action and make large investments to adapt to future climate change: half of the companies that implement soft measures also implement hard adaptation measures. The interviewed companies that implement hard adaptation measures belong to industry sectors that are reliant on long-term fixed assets – water utilities, energy producers and utilities, and mining companies. Reliance on long-term assets can require companies to consider future impacts and implement hard adaptation measures, as they lack the flexibility of companies with shorter asset lifetimes or which don't rely on assets. Three of the five interviewed businesses which implemented hard measures were utilities companies. These regulated utilities may be able to implement expensive investments in adaptation as it may be easier to finance adaptation by raising funds from their customer base. In contrast, companies operating in different markets may not be able to pass costs on to customers and finance adaptation as easily.

Water utilities

The water utilities sector has started to implement hard adaptation measures in response to climate change, particularly in the context of water management and flood prevention. The case study analysis highlighted examples of two companies implementing these types of action. Anglian Water is currently managing the impacts of the immediate risks of flooding and extreme events. The company has identified assets vulnerable to flooding and has secured investment for flood resilience works at 20 key sites. It is also investing to increase the resilience of drinking water provision by ensuring that there are multiple supply routes for areas vulnerable to interruption as a result of floods and other climate impacts.

To date Anglian Water has focused on understanding climate change risks, delivering appropriate responses to increased flooding risk, improving the resilience of the water supply network for population centres of greater than 50 000 people, and embedding adaptation assessments into its company structure. A number of investments have been approved for funding by the English and Welsh regulator Ofwat (The Water Services Regulation Authority) to allow for investment over the period from 2010 to 2015.

Anglian Water's current hard measures include:

- Water proofing infrastructure to prevent flood damage;[3]
- Raising electrical panels and other sensitive equipment above projected flood levels;
- Building whole site or asset specific flood defences to protect against projected flood events;
- Creating back-up water supply plants and interconnecting water supply zones for areas vulnerable to loss from climate events;
- Factoring climate change into the design of assets to increase their robustness.

When assessing the risks and formulating adaptation action plans, the company draws on expertise from its Innovation Team and studies by universities and research centres. It also collaborates with the UK Environment Agency, Ofwat and DEFRA. The company's business plans are then reviewed by Ofwat and other agencies such as the Consumer Council for Water and the Drinking Water Inspectorate. Stakeholder concerns are central to Anglian Water's decision making, and the company takes these into account in its proposals.

Collaboration between government regulators and water providers plays a crucial role in achieving adaptation. Compared to other sectors, the privatised English and Welsh water sector is heavily regulated, through both national and European standards and legislation. Limits to customer charges are set by the regulator to allow companies to generate sufficient income from customers to fund activities such as adaptation to climate change. Many of the key issues that affect adaptation actions need to be negotiated with government and regulators. These include the timing of investment needed to deal with the combined impacts of growth and climate change, the ability of water customers to afford the costs of adaptation, and the planning of major projects such as water resource transfers, reservoirs and treatment plants.

Veolia has also implemented hard adaptation actions. Their most advanced actions to date aim at reducing water consumption and increasing water use efficiency, and the company is also developing drinking water and wastewater management solutions. Part of Veolia's adaptation strategy includes developing alternative resources such as aquifer recharge, reuse of treated wastewater and desalination.

In Australia and Israel, Veolia Water has already been confronted with water shortages and droughts, and has developed solutions to ensure long term water supply. In Australia, Veolia has constructed a 200 km pipeline network to transport water for treatment, and has built a large-scale desalination plant on Australia's east coast, which could provide drinking water sufficient for 735 000 people per day. In Israel, Veolia has set up a desalination plant to ensure water supply continuity in the Ashkelon region (Veolia Environnement, 2008). The desalination technique has been optimised to reduce the cost of production, which is now equivalent to half the cost of importing water for irrigation found in some eastern Mediterranean regions.

Energy utilities

The energy utilities interviewed in this analysis indicated that they are highly vulnerable to climate change impacts, and some have started investing in improving their infrastructures to ensure a greater resilience to climate impacts and to avoid consequent energy supply disruptions. Adaptation decisions by energy companies have often arisen as a response to extreme events, such as Hurricane Katrina in 2005 or

[3] Since some of the engineering work necessary to adapt the infrastructure to climate change could be carbon intensive the company considers both the carbon footprint and the adaptation benefits of chosen actions in investment decisions.

the highly damaging storms in France in 1999. Responses have included building electricity transmission centres away from forests, to avoid tree damage during storms, and flood-proofing power plants. Some plants along the coasts are also sensitive to sea-level rise. Barriers have been constructed to ensure that these plants are more resilient to future climate change.

Heat waves, which are projected to become more frequent due to climate change, lead to production problems in many countries. In France, warmer than average summers from 2003 to 2006 required extensive operational changes to maintain steady power supplies from nuclear power plants, which produce the majority of France's electricity (Kopytko and Perkins, 2011). High temperatures can make it difficult to comply with regulations on thermal pollution. Whereas initially the best response was to stop production at some plants in order to comply with these regulations (Autorité de Sûreté Nucléaire, 2003; Hibbs, 2003), EDF has made efforts to adapt its power plants to avoid production interruptions. EDF is investing significantly in improving its facilities' robustness to the effects of heat waves – this infrastructure investment programme is scheduled to be completed by 2015 and is estimated to cost between EUR 300 million and EUR 420 million (ONERC, 2009).

EDF's R&D department has conducted research on more efficient cooling systems. In particular, EDF has been increasingly using close loop cooling which allows discharging at a much lower temperature than the more diffused open loop cooling (EDF, 2008). EDF has also researched more efficient techniques, such as dry cooling and ammonia bottoming cycles. Although these projects are only pilot schemes, they illustrate the company's engagement in addressing climate change issues.

Mining companies

Because of their restricted flexibility in selecting the location of their operations, mining industries have a particular need to consider future climate change and to adapt their infrastructures to cope with climate change impacts. The investment at Rio Tinto Alcan's Yarwun alumina refinery in eastern Australia provides an example of the modification of infrastructures to take future droughts and increasing water prices into consideration (Rio Tinto, n.d.). The plant's water cooling system was adjusted so that it could use both saltwater and freshwater for cooling purposes. This increases the plant's flexibility and allows it to switch to saltwater cooling during drought periods. The modified infrastructure decreases the lead time required to make a switch to seawater cooling and it ensures that there are no plant layout issues associated with the retrofit.

Figure 5. Risk Management Summary

Risk Management

- A few companies feel they are *already taking the necessary actions* to address climate change risks, and may not implement specific adaptation measures.
- Two-thirds of companies interviewed have implemented *"no-regret" and soft adaptation measures.* These are often synergistic measures, which are beneficial to companies' business operations while also increasing resilience to climate change impacts.
- Half of these companies have also implemented *hard adaptation measures* – these companies principally belong to industry sectors that are already sensitised to climate change impacts, such as water utilities, energy utilities and mining companies.
- Collaboration between the private sector and government and regulators can help incentivise and enable adaptation.
- Companies with less operational flexibility, such as mining businesses, have a particular need to consider future climate change and necessary adaptation measures.

3.4. Harnessing opportunities

In addition to posing risks, climate change also represents opportunities for businesses. Indeed, the possibility of seizing opportunities arising due to climate change seems to have spurred companies into action as much as the need to respond to future climate change impacts has – a third of the companies interviewed are aware of or already pursuing new opportunities arising from climate change. The available opportunities vary considerably across sectors and companies. A recent study from Oxfam (2009) outlines the benefits of capitalising on the new "adaptation marketplace". It encourages companies to invest in climate change preparedness and adaptation measures in several sectors, such as water management, new resistant agricultural products, insurance, disaster preparedness, coastal resource management, and climate change information and consulting services (Oxfam, 2009). Additionally, a report from GHK (2010), prepared for the UK government's 'Adapting to Climate Change Programme', identifies key opportunities for UK businesses in adaptation to climate change in the domestic and global markets. The case study analysis, and the consideration of publicly available information, has made evident several examples of opportunities for private companies across a range of sectors.

Environmental consulting services

There are many opportunities arising for climate change consulting services. Whereas in the past these consulting services have mostly focused on supporting firms in undertaking mitigation actions, they have now expanded their services to include adaptation to climate change. Many consulting firms have started to provide climate change information services to corporations or public bodies, with the aim of helping them to understand the threats of climate change impacts and to plan accordingly. Examples of adaptation related services offered by consulting groups include climate change risk assessments, general risk

assessment frameworks, climate change risk management strategies, technical and economic analysis, climate adaptation solutions, and GIS mapping and modelling.

There has been a growth of interest in providing these types of climate change consulting services, and many firms are now active in this field. For example, PricewaterhouseCoopers (PwC), who contributed to this study, offers risk assessments to help companies to identify vulnerabilities, key risks, risk management strategies and cost implications across a value chain (PwC, 2011). Consulting companies may hire climate scientists, weather forecasters and meteorologists to develop the knowledge and expertise needed to serve their clients. This also opens new opportunities in the job market for specialised and highly trained individuals. Given the close interactions between researchers and policy makers, this type of business is facilitated by dialogues and partnerships.

Agricultural technologies

While climate change represents a risk for some farmers, it offers opportunities for private companies that can provide agricultural products and services suited to resist the impacts of climate change. For example, new markets are opening for the development and production of drought resistant crop varieties and for drip irrigation systems which provide more efficient irrigation. In particular, the anticipated impacts of climate change have contributed to increasing R&D in plant breeding to face these impacts, including plant breeding to develop crop varieties that are more resistant to climate change stresses.

Companies such as Monsanto, BASF, Syngenta and Bayer are developing drought resistant seeds and crops. BASF has collaborated with Monsanto since 2007 to develop crops that are more resilient to adverse environmental conditions such as drought. R&D is focusing on corn, canola, soy and cotton crops, and the first market launch is expected in 2012. BASF is also working with the Espaço ECO Foundation in Brazil to trial the use of 'superabsorber polymers' in a reforestation project in the Brazilian rain forest. These polymers have a high water absorption capacity and are normally used in baby diapers or other hygiene products. They can also store water in soil and thereby increase water storage capacity, an important property if climate change affects the availability of water for plants.

The development of crops that are resistant to environmental stresses is an area where collaboration between governments and companies can support private sector engagement. There are many examples of public private partnerships (PPPs) in this field of agricultural development. For example, the Drought Tolerant Maize for Africa (DTMA) project, initiated by the International Maize and Wheat Improvement Centre (CIMMYT), aims to expand efforts to provide drought-tolerant maize varieties to poor farmers in Sub-Saharan Africa. The DTMA project aims to achieve its goals of increased drought resistance in maize crops, higher crop productivity and broader reach to farmers through collaboration between scientists from the CIMMYT, research institutes, NGOs and private sector seed companies such as Dryland Seeds Ltd in Kenya and Tanseed International Ltd in Tanzania (DTMA, n.d.). PPPs such as the DTMA initiative can thus enable the private sector to engage in new opportunities arising due to climate change, while also helping other private sector operators adapt to climate change impacts and enabling public sector organisations to fulfil their own goals.

Water management and technologies

The water sector offers many opportunities in the area of innovative technologies related to adaptation, around issues such as water management, distribution and drainage. For example, it was estimated that the market value of goods and services to the UK water and wastewater sector was almost GBP 8 billion in 2007/08, constituting 36% of the entire UK environmental services market (GHK, 2010). This includes companies that provide water conservation technologies, sustainable drainage systems, water

reuse and recycling systems, desalination plants, rainwater tanks, and water purification systems for use in disaster situations.

For example, through its SUEZ Environnement subsidiary GDF SUEZ is involved in providing solutions for adapting to climate change impacts through the development of desalination systems, the reuse of "regenerated" wastewater, the use of simulation tools, the management of aquifer recharge, and the reduction of water leakages. SUEZ Environnement has constructed more than 250 desalination plants over the past 40 years. Desalination is increasingly required in North Africa and in the Middle East, and although desalination is an energy-intensive process in some circumstances it may be the only viable solution to climate change-induced water shortages. Additionally, SUEZ Environnement estimates that more than half of the world's population lives less than 100 km from coastal regions, offering clear opportunities for desalination services. SUEZ Environnement conducts wastewater "regeneration" activities worldwide, reusing treated wastewater for irrigation, for industrial water processes, for water cooling and in the production of "soft" water. Reuse of treated wastewater is therefore a means to reduce water extraction and usage. In the face of current temporary and chronic water deficits due to increasingly frequent and prolonged droughts, water reuse is considered as a strategic alternative resource worldwide. SUEZ Environnement's simulation tools can be used to model surface and underground water resources, which enables the production of a "master plan" of water and wastewater systems and assists in the optimization of water use.

The built environment

Multiple opportunities exist for implementing adaptation measures across the built environment and construction sector. For example, building and real estate companies can foster innovative design and new design practices to improve the resilience of buildings to the impacts of climate change. These could reduce the impacts of climate change on energy demand. Other examples of technologies that could help adapt to climate change impacts include domestic flood defences, cooling systems, water recycling systems, and "green roofs" (which are partially or completely covered with vegetation).

Climate proofing and improvement of infrastructure vulnerable to climate change impacts offers opportunities for companies involved in construction and public works. One example is the company Etudes et Projets Industriels (EPI), a small French company which responds to requests by private and public entities, in particular in the sector of public infrastructural works.

One of the fields in which EPI engages is the improvement of the electricity network by installing new underground electricity cables. These works have an aesthetic purpose, but are also carried out to improve the resistance of the electricity network to extreme climate events. For example, in France requests for electricity cables to be moved underground have increased since the storms in 1999-2000. These storms caused damages to the electricity network and power cuts that could have been reduced or eliminated had power been provided through underground cables.

The demand for these works comes from companies responsible for electricity distribution, such as Électricité Réseau Distribution France (ERDF), and from public entities, such as city councils and city council unions. From the political point of view, the annual works for the installation of underground electricity cables have been concluded between ERDF and the city councils, which are often supported by regional public bodies. For instance, the SIPPEREC (Syndicat Intercommunal de la Périphérie de Paris pour l'Électricité de les Réseaux de Communication) is a union of 36 city councils of the Paris suburbs, which is responsible for urban communication, renewable energy, and regional infrastructure. The SIPPEREC states in the description of its activities that the 1999 storms have shown the fragility of the above-ground electricity network, and it supports the subsidisation of works for the creation of underground electricity networks. At the end of 2009 the cumulative expenditure on moving cables

underground amounted to EUR 27.2 million since 2004, covering 128 km of the electricity distribution network (SIPPEREC, 2009).

EPI also works in other adaptation-relevant areas. For instance, they are active in the markets for improvement of building isolation, heating and cooling. Improvements in these areas will limit future changes in energy demand due to increasing temperatures. Requests for such operations are increasing, due in part to increasingly strict French building standards regulations.

Although this example illustrates a company acting at local level, similar opportunities are also available at larger scales or in other sectors, such as water distribution, sewage systems and transportation. Companies may therefore be able to take advantage of multiple and varied opportunities to carry out climate proofing of the built environment.

Other sectors

Relevant business opportunities could also arise in other sectors. For instance, climate change could present opportunities in *insurance markets*. Many insurance companies have been developing specific insurance products to mitigate the risks of climate change, such as risk transfer mechanisms, weather related insurance and catastrophe bonds, and weather index-based insurance for developing countries. Several insurers and re-insurers have seen the potential opportunities arising from the consequences of climate change, including Swiss Re, Munich Re, AXA, Lloyd's, and Aviva among many others.

A trial project in Thailand is currently testing weather index insurance against climate change impacts. This type of insurance is innovative as it is based on measurable weather outcomes, which limits farmers' losses due to disasters or damaging weather conditions, while being easier to administer than alternative insurance schemes and retaining the incentive for farmers to limit their exposure to losses. In Thailand, Sompo Japan Thailand, a subsidiary of the Japanese insurance agency Sompo Japan, and the Thai financial agency Bank for Agriculture and Agricultural Co-operatives (BAAC) are currently providing 'Weather Index Insurance' for drought risk in selected Thai provinces. Sompo Japan Thailand started selling insurance contracts in January 2010, with BAAC acting as an intermediary between Sompo Japan Thailand and local rice farmers. The insurance contracts, developed in conjunction with the Japan Bank for International Co-operation (JBIC), have been designed to pay out to farmers in the event of drought. Drought is indicated, and payouts triggered, if the observed accumulated rainfall over the period from July to September falls below a pre-determined set level (Sompo Japan, 2010). The trial was launched in one Thai province in 2010 and expanded into four additional provinces in 2011, with over six thousand insurance contracts issued in 2011. The trial is set to run until January 2012, when Sompo Japan Thailand intends to review the outcomes of the trial and will consider revising the insurance product, diversifying the types of crops for which it is available, and expanding its availability in other Thai provinces and in other Southeast Asian countries (Sompo Japan, 2011).

This example also highlights the potential role of partnerships between the private and public sector in opening up new opportunities arising due to climate change. The publicly-financed JBIC played a role in the development of the insurance contracts, and has also identified several key areas where action by public bodies would be necessary to help establish a global weather-based insurance system (JBIC, 2007). Public organisations can therefore play a role in enabling the private sector to pursue new business opportunities brought about by climate change, in addition to encouraging adaptation.

Information services could also offer innovative products for disaster preparedness and recovery. Early warning systems, weather forecasting tools, and risk mapping technologies are all in increasing demand. Google provides an interesting example of activity in this area. The company recently named 21 "Google Science Communication Fellows", a collection of early- to mid-career scientists who will discuss

technology and science communication and will be able to apply for grants from Google in order to put their ideas into practice (Google, 2011). Google has also used existing tools to raise awareness of climate change issues. Narrated discussions of climate change issues and tours of climate change scenarios and impacts and options for mitigation and adaptation have been produced using Google Earth (Google, n.d.). Another example where companies can provide information services is provided by Swiss Re. The company has developed CatNet™, an online natural hazard information and mapping system, which enables clients to assess natural hazard exposure for any location worldwide. Natural hazard information is combined with Google maps and satellite imagery to provide Swiss Re's clients with tool to help prepare local, regional and cross-regional risk profiles.

3.5. Common trends and factors affecting engagement

This analysis shows that many interviewed companies are aware of climate change impacts and are involved in climate change adaptation discussions. The majority of companies interviewed also systematically assess the impacts of climate change on their business. However, fewer of the surveyed companies thoroughly assess such impacts with the use of climate models, and companies usually consider only short-term risks and do not take future climate scenarios and long-term risks into consideration. A smaller number of companies go beyond assessment and implement adaptation actions to manage identified risks. The majority of these actions are "no regrets" or soft measures, though some companies implement hard measures. Although these results are based on an analysis of a small selection of companies, they provide interesting information about companies' experiences in assessing risks and implementing adaptation and offer a good indication of trends within the private sector. The trends identified by this analysis are supported by the results of a meta-analysis of businesses' responses to questionnaires from the CDP (Box 3).

The CDP is an independent not for profit organisation which compiles and holds a database of corporate climate change information. The CDP annually requests information from over 2500 companies in 60 countries and distributes information on the business risks and opportunities presented by climate change. This data is made available for use by a wide audience, including institutional investors, corporations, policy makers, public sector organisations, government bodies, academics and the general public. The 2009 CDP questionnaire (CPD7) focuses primarily on greenhouse gas emissions and energy use, but also includes questions relating to climate risk management (CDP, 2009). By analysing companies' responses to the CPD7 questionnaire, it is possible to obtain high-level data on the private sector's level of engagement in adaptation to climate change, the types of risks that concern companies, and the types of measures being implemented.

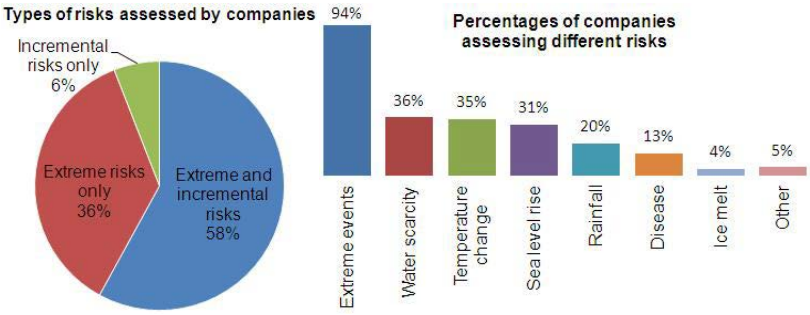
Box 3. A meta-analysis of Carbon Disclosure Project 2009 (CDP7) questionnaire responses

The CDP7 questionnaire, which primarily addresses companies' efforts to mitigate greenhouse gas emissions, includes several questions on the risks companies face due to climate change as well as the ways companies act to address such risks. Analysing the responses to these questions provides an overview of companies' perceptions of risks associated with climate change, some of the preventative measures that have been considered by companies, and insights into the reasons underpinning decisions to implement adaptation measures.

Risk Awareness

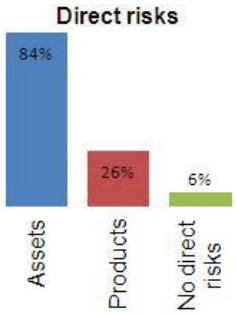
Of the 1100 English language company responses to the CDP7 questionnaire, 75% of companies consider physical risks arising from climate change, 23% do not consider themselves exposed to physical risks, and 2% do not know. Of the companies that acknowledge physical risks, the majority (59%) do not take any further action to either assess or manage such risks. Two fifths of these companies (41%) acknowledge and assess climate change risks and opportunities. This analysis indicates that there appears to be widespread awareness of the physical impacts of climate change. However, there is a sizeable gap between awareness and assessment of risks, and a larger gap between awareness and action on adaptation to climate change.

Risk Assessment

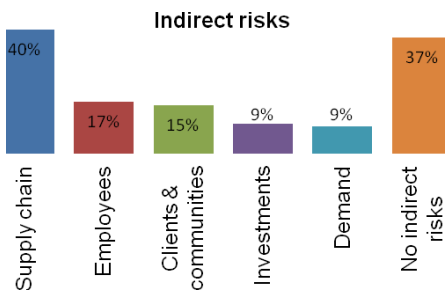


The majority of companies consider risks from both climate extremes and incremental changes. A third of companies only consider extremes, and a few only consider incremental risks. The primary concern is extreme weather events. Incremental changes are often considered as secondary and too uncertain to be accounted for in management decisions.

Of the companies that assess climate change risks, 94% consider direct impacts of climate change and 63% take into account indirect impacts and broader implications.



A large majority of companies (84%) are concerned with direct risks to assets, and more than a quarter of companies (26%) are concerned with direct risks to products (17% are concerned with both types of direct risk).



Supply chain risks (e.g. declining raw material availability, rising transportation costs) are the primary indirect risks faced by companies. However, many companies (37%) assess no indirect risks from climate change, and other risks are less frequently perceived.

Risk Management

Less than a fifth of companies (17%) which assess risks and opportunities take further actions to manage climate change risks (equating to only 7% of those aware of risks). Risk management measures range from improvements in business practices to investments in infrastructures and technologies. The majority of companies (84%) implement soft adaptation measures (usually "no regret" options such as commercial changes in products and services, strategic changes, and financial planning) whereas a sizable minority (45%) implements hard adaptation measures (large-scale planning and investments with high irreversibility). Just less than one third of companies (29%) implement both types of measure. The greater investment in soft measures can be explained by lower implementation costs and easier adjustability of measures as new information and data becomes available – flexibility is important to most businesses as it allows them to follow market stimuli while limiting the risk of making unprofitable investment choices.

Source : www.cdpproject.net, Authors' analysis of CDP7 questionnaire responses

The case study analysis has indicated that companies' decisions to adapt to climate change can depend on various factors, ranging from business characteristics and location, to the ease of implementation of adaptation, the collaborative mechanisms between businesses and government, and the regulatory environment. The analysis of companies' experiences has identified factors that facilitate or incentivise adaptation, and factors which may hinder private sector adaptation.

While most of these findings represent general factors or barriers which affect all private sector companies, some are particular to specific firms or industries. Additionally, some of the factors limiting engagement in adaptation may not be reflective of failures on the part of businesses, but may be rational given companies' circumstances. Given certain circumstances or the manner in which certain companies operate, it may be rational for them not to implement adaptation actions. However, in cases where inhibitory factors are not rational business responses, it may be possible for governments or regulators to act to encourage and support adaptation. Indeed, this analysis has identified several examples of the roles that governments and public bodies can play in promoting private sector engagement in adaptation to climate change.

The factors identified by the case study analysis that affect private sector engagement in adaptation can be broadly classified according to their impact in three areas: companies' *capacities* to implement adaptation, their *incentives* for action, and their *perspectives* towards the need to adapt.

3.5.1. Capacities

There are several factors which can affect companies' financial and technical capacities, and thereby influence their ability to adapt to climate change. Companies' *ability to finance adaptation* can significantly affect their engagement – companies often state that a main reason for not implementing risk management actions is the high costs of the adaptation options they have considered. Many of the businesses that do implement adaptation actions are those companies that have been publicly subsidised or that have found it easier to pass on the costs to consumers. For example, energy utilities may be partly subsidised by governments, which can better enable them to climate-proof their infrastructure. This issue may not equally affect all areas of the private sector. For example, as water utilities in England and Wales are regulated regional monopolies they are able to include costs towards adaptation when setting customer prices, meaning that the issue of the high cost of adaptation investments may be less of an issue for them. However, in general companies which are better able to finance adaptation appear more likely to implement measures.

Companies which possess *in-house capacity and analytical expertise* may be more likely to take action on climate change, as they may be better able to undertake risk assessments and to consider possible adaptation actions. Conversely, companies which do not possess in-house capacity and do not have experience in carrying out risk assessments may be slower to implement adaptation actions. In addition to using pre-existing capacity, several companies have also started investing in specific climate change-relevant expertise in order to build the necessary knowledge and core competences to deal with climate change within the company. For instance, EDF has greatly invested in research and model development, focusing particularly on hydraulic resources, river and marine modelling, and statistical modelling of extreme events. The presence of pre-existing capacity or expertise within companies, and the development of specific climate change-relevant capacity, may therefore be indicative of companies that are both better able to and more likely to consider and implement adaptation actions.

The institutional context in which companies operate can significantly influence private sector engagement. The presence of climate change R&D infrastructure, such as government initiatives promoting research on modelling climate scenarios, on climate change impact analysis, and on downscaling from global to regional models, can facilitate decision making and encourage adaptation

actions. Additionally, private sector partnerships with the public sector, scientific organisations and academia can facilitate adaptation by providing companies with guidance, information and shared capacity to help them adapt. For example, the UK has various partnerships and centres in place to help businesses understand climate change science and to provide them with the best available information, and also provides support, guidance and tools for companies to consider their vulnerability to climate change and to produce adaptation plans. Water companies in the UK often collaborate with government and with research centres, and energy utilities that have close links to research organisations and to the government are generally active in the climate change field. The IMFREX project in France also highlights the benefits of undertaking shared research projects, as it enables all participants to profit from pooled research capacities. Partnerships with public bodies might also enable the private sector to take advantage of new opportunities brought about by climate change.

3.5.2. Incentives

Several common factors affect companies' incentives to adapt to climate change. *Uncertainties around climate impacts* can inhibit companies' investments in adaptation. As companies' investment decisions are based on assessments of costs vs. benefits, they may be reluctant to commit to significant up-front investments given uncertainties around the extent of the end benefits. Businesses therefore have less incentive to invest in adaptation when the climate change impacts it protects against are uncertain or when there is a large range in the possible severity of impacts. This factor is applicable across the whole private sector, but is especially salient when impacts are expected only to occur in the long term, or when adaptation requires significant investment. This may explain why many examples of adaptation measures implemented by companies concern activities relating to climate impacts with low uncertainty, such as increasing temperatures and increasing frequency of heat waves.

Companies' engagement in adaptation is affected by the degree of *operational flexibility* they posses. A company will be more likely to implement large-scale adaption measures if it faces restricted choices about the adaptation options available to them. The extent to which this is an important factor for companies varies depending on the industry or sector they operate in. Whereas some sectors, such as retailing, can adapt to climate variability relatively easily by adjusting their production or supply sources, other businesses are locked into their assets. This is the case for mining companies or gas and oil extraction companies, whose operating location choices are limited by the location of natural resource extraction sites. In these cases, where companies may not able to adapt easily by switching locations or by implementing soft or "no regret" measures, companies have a greater incentive to implement larger-scale or more costly adaptation actions.

The *policy and regulatory environment* in which a company operates influences corporate decision making to a large extent. Regulation can explicitly compel companies to take adaptation into account – the UK's Adaptation Reporting Power is an example of this. More generally, regulations that have been implemented for other reasons can have a strong influence on companies' adaptation choices. These include: building standards, water temperatures limits, water quality standards, price ceilings and security regulations. For example, the water sector in England and Wales is highly regulated, through different regulatory agencies such as Ofwat, the UK Environment Agency and the Drinking Water Inspectorate (Ofwat, 2009). Ofwat monitors water companies and identifies the future challenges to which the industry is exposed. Among these challenges Ofwat highlights the need to adapt to future climate change impacts and requires the companies to set up plans for adaptation. However, while regulation can promote adaptation, inconsistencies in regulation or uncertainty about the future regulatory environment can be a cause of uncertainty to companies and may even be a barrier to implementing adaptation (Anglian Water, 2011). Consistency and predictability of regulation is therefore important if it is to be effective in encouraging adaptation.

The *business planning horizons* used by companies can also influence their incentives for action – the relatively short business planning horizons used can limit companies' engagement. For many business activities the planning horizon does not extend beyond five years. Timeframes of this length will not be forward-looking enough to consider long-term climate change impacts, and companies will be less likely to adapt to impacts that have not entered into their business planning procedures. This may therefore limit adaptation, especially as many climate change impacts can be expected to only occur in the long term. However, there are some exceptions which show that, where necessary, companies may consider long term climate change issues. For example, power plants usually have an operating lifespan of 50-60 years, which means that future water availability or possible sea level rises need to be considered during their planning and construction.

3.5.3. Perspectives

Several factors can influence companies' perspectives on the need to adapt to climate change. These factors do not affect companies underlying ability or incentives to adapt, but can nonetheless influence companies views on the need to adapt. Companies may be more likely to engage in adaptation if they have *previous negative experiences of natural disasters or extreme climate conditions*. Experience of the significant economic costs that can arise from such events may encourage companies to consider the possible impacts of climate change on their business operations. This is especially true if companies feel that climate change is likely to lead to recurrences or escalations of the same events they previously experienced. Two striking examples where experiences of previous natural disasters or extreme events have led to adaption are those of Entergy, and of RTE and EDF. Entergy's losses due to Hurricane Katrina spurred the company to assess the risks that climate change presents for its business. EDF and RTE both suffered from storms in 1999 as well as the 2003 European heat wave. These events influenced both companies' decisions to implement adaptation.

Similarly, companies with *previous experience of managing climate sensitivities*, such as those operating in locations with harsh climatic conditions or with installations which are highly sensitive to climatic conditions, may be more likely to implement adaptation measures. Climate change may increase the climatic problems faced by such companies, but they will already be familiar with the need to adapt to their operating environments, and are likely already aware of the types of actions and measures that will need to be undertaken. For instance, this is the case with mining companies, which analyse climatic impacts on business operations in the face of existing conditions. These companies have long been aware of the need to invest in water management, and in this context climate change will increase the need to implement adaptation measures. As these companies were aware of the need to invest in water management even before considering climate change, they may be more likely to undertake adaptation to the additional impacts due to climate change.

The *framing of climate change risks versus opportunities* can also affect companies' engagement – companies appear to find it easier to invest in adaptation when this presents opportunities rather than costs. For example companies developing drought-resistant crops or other new solutions for agriculture are among the ones with the greatest engagement in climate change. This is also linked to the time horizons companies follow in business planning: it will be easier for a company to incorporate opportunities that it will be able to seize in the short term, rather than to invest in long-term projects with uncertain outcomes.

4. CONCLUSION

This paper has analysed the experiences of a set of companies in engaging in adaptation to climate change. The selected companies provide a varied sample of private sector organisations which are active on climate change issues. Companies included in the analysis operate in a broad range of industries, including utilities services, manufacturing, retail, mining and financial services. Companies represent both small- and large-scale businesses, and operate at differing scales and across a range of operating locations. The case study analysis was supplemented with information from publicly available materials, supporting literature, and an analysis of responses to the 2009 CDP climate change questionnaire. While companies' individual actions and motivations are affected by their specific operating contexts, the common themes and factors identified through this analysis are broadly applicable to the private sector.

The analysis considered three different tiers of engagement in adaptation: (1) risk awareness, (2) risk assessment and (3) risk management. The analysis finds that companies are generally aware of the risks that climate change poses to their business. They have also often engaged in assessing current and future climate change impacts, although not all companies which are aware of risks also conduct assessments. The consideration of current climate change impacts is more common as companies often already consider existing climate risks as part of general risk assessments. Not all companies have undertaken risk management measures or implemented adaptation actions. There are several examples of companies implementing no-regret or synergistic adaptation measures, but larger investments in adaptation going beyond no-regret measures are less common. Additionally, several companies are starting to take advantage of new opportunities for products and services arising due to climate change. These opportunities range from the provision of climate change consulting services to the climate proofing of infrastructure.

There are several factors which can influence companies' capacity to adapt, their incentives to implement actions, and their perspectives on the need to manage climate change risks. While some of these factors may be rational business responses, there are cases where governments can act to encourage adaptation.

The inability to finance adaptation can be a key barrier to adaptation, and companies appear to be more able to adapt if they can offset costs, for example if they are able to pass on the costs of adaptation to consumers or if they receive subsidies to help them defray the costs of adaptation. The presence of in-house capacity and previous experience of the need to address climate variability also facilitates the implementation of adaptation measures. Given the substantial research requirements involved in the identification of climate sensitivities and adaptation options, government support for research, the provision of guidance and tools, dialogues and linkages between research centres and government experts, and knowledge networks between the private sector and academia can support companies' implementation of adaptation. In this context, partnerships between the private sector and governments, scientific organisations and academia may be effective instruments for enabling adaptation.

The uncertainty of future climate impacts and the short-term horizon used in many business planning processes can reduce companies' incentives to adapt. Businesses' operating environments can also affect incentives for adaptation, although such factors may not affect all companies as their importance will vary depending on specific company and industry contexts. Companies with high flexibility in their operations may be able to adjust to climate conditions relatively easily without implementing specific adaptation

measures, whereas companies that are heavily dependent on specific climate-sensitive resources will have more of an incentive to implement hard adaptation measures. Regulatory environments and government actions can play a key role in stimulating private sector engagement in adaptation. Regulations can incentivise or oblige companies to take actions to address climate change, as illustrated by the encouragement to act on adaptation provided by the English and Welsh water industry regulators.

Companies' perspectives on the need to adapt can be influenced by their previous experiences – companies that have already experienced negative impacts due to current climate variability and extreme events tend to be more engaged in climate change adaptation. It also appears that companies that can seize opportunities from adaptation may also be more engaged in the climate change adaptation field.

Given the risks and vulnerabilities across all industry sectors and the significance of expected climate change impacts on businesses, the private sector will have a significant role to play in implementing adaptation to climate change. However, companies' vulnerabilities, adaptive capacities and incentives for action will be influenced by the markets and regulatory contexts they operate in. This analysis has identified several instances where the public sector has acted to enable and encourage adaptation, and possible future opportunities for public sector action. The case study analysis has indicated that the public sector has supported adaptation through developing R&D infrastructures and entering into partnerships with the private sector. These have provided companies with information and guidance to assist decision-making, and have enabled organisations to pool capacities to better enable risk assessments and management. In some instances, the public sector has also used regulatory frameworks to encourage the private sector to develop adaptation strategies. The approaches taken by governments in these instances may provide examples for other public sector organisations that wish to stimulate private sector engagement.

The public sector can also encourage and assist private sector adaptation by addressing the barriers to action identified in this analysis. A key role for the public sector is to help provide companies with the information they need to take account of climate risks. Public sector institutions do not necessarily need to produce this scientific information themselves, but can act as intermediaries to facilitate information exchange between scientific and business communities and to make information more understandable and accessible for non-technical end users (Corfee-Morlot *et al.*, 2011). Additionally, the public sector can assist private sector decision-making by providing risk-management guidance and tools that are adapted to suit different users' needs.

The results of this analysis results suggest three potential areas where future research may be beneficial. Firstly, future analysis could consider the economic case for adaptation through an examination of how closely observed levels of adaptation match the efficient level. It could also consider the costs and benefits of taking early action to address climate change versus delayed responses. This analysis could also help guide governments' policy decisions and help identify when the public sector can play a role in assisting adaptation. Secondly, research could help improve understanding of how companies' actions to respond to current climate variability could help or hinder their responses to future climate change. Thirdly, future work could provide a better understanding of the interplay between public and private sector adaptation strategies, and of possible synergies or conflicts between them.

REFERENCES

Acclimatise (2009a), *Building Business Resilience to inevitable Climate Change. Carbon Disclosure Project Report 2008. FTSE 350.*, Acclimatise, Oxford.

Acclimatise (2009b), *Building Business Resilience to inevitable Climate Change. Carbon Disclosure Project Report. Global Electric Utilities.*, Acclimatise, Oxford.

Acclimatise (2009c), *Building Business Resilience to inevitable Climate Change. Carbon Disclosure Project Report 2008. Global oil and gas.*, Acclimatise, Oxford.

Acclimatise (2010), *Building Business Resilience to inevitable Climate Change. Carbon Disclosure Project Report. Global Mining.*, Acclimatise, Oxford.

Acclimatise *et al.* (2009), *Managing the Unavoidable: Investment Implications of a Changing Climate*, www.uss.co.uk/Documents/Managing%20the%20Unavoidable%20-Investment%20implications%20of%20a%20changing%20climate%20Nov%202009.pdf, accessed 11 August 2011.

Andreassian, V. *et al.* (eds.) (2006). *Large Sample Basin Experiments for Hydrological Model Parameterization: Results of the Model Parameter Experiment – MOPEX*, International Association of Hydrological Science, Publication 307.

Anglian Water (2009), *Strategic Direction Statement 2010-2035*, www.anglianwater.co.uk/_assets/media/strategic-direction-statement.pdf, accessed 11 August 2011.

Anglian Water (2011), *Climate Change Adaptation Report January 2011*, Anglian Water, http://archive.defra.gov.uk/environment/climate/documents/water-comp-adapt-plan/wc-anglian.pdf, accessed 22 August 2011.

Autorité de Sûreté Nucléaire (2003) "Chapitre 11: Les centrales électronucléaires", *Rapport annuel 2003*, Autorité de Sûreté Nucléaire, Paris, pp.265–344.

Bayer (2010a) *What's up with the Earth: The mystery of early spring*, Bayer, www.climate.bayer.com/en/wuwte-complete.pdfx, accessed 11 August 2011.

Bayer (2010b) *Winners of the 19th International Children's Painting Competition*, www.unep.bayer.com/en/international-children_s-painting-competition-19.aspx, accessed 11 August 2011.

Berkhout, F., J. Hertin and N. Arnell (2004), *Business and Climate change: Measuring and Enhancing Adaptive Capacity – The ADAPT project*, Tyndall Centre Technical Report No.11, February 2004, www.tyndall.ac.uk/content/business-and-climate-change-measuring-and-enhancing-adaptive-capacity, accessed 12 August 2011.

Burton, I. (1996), "The growth of adaptation capacity: practice and policy", in Smith, J. *et al.* (eds.) *Adapting to Climate Change: An International Perspective*, Springer-Verlag, New York, pp.55–67.

CCSP (Climate Change Science Program) (2007) *Effects of Climate Change on Energy Production and Use in the United States*, U.S. Climate Change Science Program and the subcommittee on Global Change Research, Department of Energy, Office of Biological & Environmental Research, Washington DC, www.climatescience.gov/Library/sap/sap4-5/final-report/sap4-5-final-all.pdf, accessed 11 August 2011.

CDP (Carbon Disclosure Project) (2009), *CDP 2009 (CDP7) Information Request*, Carbon Disclosure Project, https://www.cdproject.net/CDP%20Questionaire%20Documents/CDP7_2009_Questionnaire.pdf, accessed 12 August 2011.

Ceres (2009), *Water Scarcity and Climate Change: Growing risks for Businesses and Investors*, Ceres, Boston MA, www.ceres.org/resources/reports/water-scarcity-climate-change-risks-for-investors-2009/view, accessed 11 August 2011.

Corfee-Morlot *et al.* (2011) "Multilevel risk governance and urban adaptation policy", *Climatic Change – Special Issue: Understanding Climate Change Impacts, Vulnerability and Adaptation at City Scale*, Vol.104 No.1, pp.169-197.

David Suzuki Foundation (2009), *Climate Change and Canadian Mining: Opportunities for Adaptation*, David Suzuki Foundation, Vancouver, www.davidsuzuki.org/publications/downloads/2009/Climate_Change_And_Canadian_Mining.pdf, 11 August 2011.

DTMA (Drought Tolerant Maize for Africa Initiative) (n.d.), *The Drought Tolerant Maize for Africa Initiative*, http://dtma.cimmyt.org/, accessed 11 August 2011.

EDF (n.d.), *EDF and the Global Compact*, www.edf.com/html/GlobalCompact/uk/environnement.html, accessed 11 August 2011.

EDF (2008), *Ammonia bottoming cycle project*, presentation at EPRI Workshop on Advanced Cooling Technology, July 2008, http://mydocs.epri.com/docs/AdvancedCooling/PresentationsDay2/9_AmmoniaBottomingCycle_David.pdf, accessed 11 August 2011.

Entergy (2010), *Building a Resilient Energy Gulf Coast: Executive Report*, http://entergy.com/content/our_community/environment/GulfCoastAdaptation/Building_a_Resilient_Gulf_Coast.pdf, accessed 11 August 2011.

Entergy (2011), *Forces of Nature Come and Go. Entergy's Preparation Never Stops.*, http://stormcenter.entergy.com/archive/2011/08/01/operation-storm-ready.aspx, accessed 11 August 2011.

Garçon, R. (1996), "Prévision opérationnelle des apports de la Durance á Serre-Ponçon á l'aide du modèle MORDOR", *La Houille Blanche*, No.5, pp.71-76.

GHK (2010), *Opportunities for UK Business from Climate Change Adaptation*, prepared for DEFRA, UK, http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=1

7072&FromSearch=Y&Publisher=1&SearchText=GA0403&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description, accessed 11 August 2010.

Google (n.d.), *Climate change in Google Earth*, www.google.com/landing/cop15/, accessed 11 August 2011.

Google (2011), *Making sense of science: introducing the Google Science Communication Fellows*, http://blog.google.org/2011/02/making-sense-of-science-introducing.html, accessed 11 August 2011.

Hibbs, M. (2003) "EDF permitted to raise discharge temperatures at six nuclear sites", *Nucleonics Week*, Vol.44 Issue 3.

Hoffman, A.J. and J.G. Woody (2008), *Climate Change: What's your Business Strategy*, Harvard Business School Press, Boston, MA.

IFC (International Finance Corporation) (2010a), *Climate Risk and Financial Institutions: Challenges and Opportunities*, IFC, Washington DC, www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/p_ClimateRiskandFIsFullreport/$FILE/IFCClimate_RiskandFIs_FullReport.pdf, accessed 7 October 2011

IFC (2010b), *Climate Risk and Business: Practical Methods for Assessing Risk*, IFC, Washington DC, www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/p_climatRiskAndBusiness/$FILE/IFC_ClimateRiskandBusiness.pdf, accessed 7 October 2011

IFC (2011), *Climate Risk and Business: Ports*, IFC, Washington DC, www.ifc.org/ifcext/sustainability.nsf/AttachmentsByTitle/p_ClimateRiskandBusiness-Ports/$FILE/IFC+Climate+Risk+-+Muelles+el+Bosque.pdf, accessed 7 October 2011

IMFREX (2005*), Impact des changements anthropiques sur la fréquence des phénomènes extrêmes de vent de température et de précipitations: Rapport final*, http://imfrex.mediasfrance.org/web/documents/downloads/rapport_final_imfrex.pdf, accessed 11 August 2011.

Ipsos MORI (2010), *Climate Change Adaptation: A Survey of Private, Public and Third Sector Organisations*, http://randd.defra.gov.uk/Default.aspx?Menu=Menu&Module=More&Location=None&ProjectID=17519&FromSearch=Y&Publisher=1&SearchText=GA0406&SortString=ProjectCode&SortOrder=Asc&Paging=10#Description, accessed 29 September 2011.

JBIC (Japan Bank for International Cooperation) (2007), *Study on Market-based Adaptation - the Potential of Index-based Insurance*, www.jbic.go.jp/en/report/reference/2007-001/jbic_RRE_2007001.pdf, accessed 11 August 2011.

Kopytko, N. and J. Perkins (2011), "Climate change, nuclear power, and the adaptation–mitigation dilemma", *Energy Policy*, Vol. 39: 318-333.

KPMG (2008), *Climate Changes Your Business: KPMG's review of the business risks and economic impacts at sector level*, KPMG, The Netherlands, www.kpmg.com/Global/en/IssuesAndInsights/ArticlesPublications/Documents/Climate-changes-your-business.pdf, accessed 11 August 2011.

Lash, J. and F. Wellington (2007), "Competitive Advantage on a Warming Planet", *Harvard Business Review*, Vol. 85, Issue 3, pp 94-102.

Long, G., S. Zadek and J. Wickerham (2009), *Advancing Sustainable Competitiveness of China's Transnational Corporations*, AccountAbility, London.

Mills, R. (2009), "Way ahead", *Rio Tinto Review*, Issue 89 March 2009, pp.15-16, www.riotinto.com/library/review_magazine.asp, accessed 12 August 2011.

NBS (Network for Business Sustainability) (2009), *Concepts and Theories: Business Adaptation to Climate Change*, NBS, London, Ontario, http://nbs.net/wp-content/uploads/NBS_ClimateAdaptation_Concepts_2009.pdf, accessed 12 August 2011.

Ofwat (2009), *Future Water and Sewerage Charges 2010-15: Final determinations*, Ofwat, Birmingham,www.ofwat.gov.uk/pricereview/pr09phase3/det_pr09_finalfull.pdf, accessed 12 August 2011.

ONERC (Observatoire National sur les Effets du Réchauffement Climatique) (2009), *Evaluation du Coût des Impacts du Changement Climatique et de l'Adaptation en France – Rapport de la seconde phase: Partie III – Rapports des groups sectoriels*, www.developpement-durable.gouv.fr/IMG/pdf/partie_3_rapports_des_groupes_sectoriels.pdf, accessed 30 September 2011.

Ouranos (n.d.), *Background*, www.ouranos.ca/en/our-organisation/background.php, accessed 23 August 2011.

Ouranos (2010), *Ouranos inaugure une nouvelle entente avec Rio Tinto Alcan*, www.ouranos.ca/fr/nouvelles/fiche.php?id=62, accessed 23 August 2011.

Oxfam (2009), *The new adaptation marketplace: climate change and opportunities for green economic growth*, Oxfam America, Boston MA, www.oxfamamerica.org/publications/the-new-adaptation-marketplace, accessed 12 August 2011.

Paquet, E. (2004), "Évolution du modèle hydrologique MORDOR: modélisation du stock nival à différentes altitudes", *La Houille Blanche*, No.2, pp.75-82.

Parsons Brinckerhoff (2009), *Energy network infrastructure and the climate change challenge, report to the Energy Networks Association*, Energy Networks Association, Barton ACT, www.ena.asn.au/udocs/2010/11/PB-Report-and-Note.pdf, accessed 12 August 2011.

Pew Center on Global Climate Change (2008), *Adapting to Climate Change: A Business Approach*, Pew Center on Global Climate Change, Arlington VA, www.pewclimate.org/business-adaptation, accessed 12 August 2011.

PwC (PricewaterhouseCoopers) (2010), *Business leadership on climate change adaptation: Encouraging engagement and action*, PwC, London, www.pwc.co.uk/eng/publications/adapting-to-climate-change.html, accessed 12 August 2011.

PwC (2011), *Climate Risks and Adaptation*, www.pwc.co.uk/eng/services/adaptation.html#ns_source=site_search, accessed 11 August 2011.

Ranger, N. *et al.* (2010) *Adaptation in the UK: a decision-making process*, www.cccep.ac.uk/Publications/Policy/docs/PB-adaptationUK-ranger.pdf, accessed 27 September 2011.

Rio Tinto (n.d.), *Rio Tinto and Water*, www.riotinto.com/documents/RTandWater.pdf, accessed 11 August 2011.

Rio Tinto Alcan (2010), *Rio Tinto Alcan unveils new research partnership with Ouranos climate change consortium*, www.riotintoalcan.com/ENG/media/media_releases_1923.asp, accessed 23 August 2011.

RTE (2009), *Energy saving back on the agenda! More!*, http://clients.rte-france.com/lang/an/clients_producteurs/services/actualites.jsp?id=9345&mode=detail, accessed 11 August 2011.

RTE (2011), *Analyse Prévisionnelle Été 2011*, www.rte-france.com/uploads/media/pdf_zip/publications-annuelles/RTE-analyse-ete2011.pdf, accessed 11 August 2011.

Severn Trent Water (2009), *Final Business Plan: Part A Company Strategy – April 2009*, www.stwater.co.uk/upload/pdf/SVT_-_PR09_-_FBP_-_A.pdf, accessed 11 August 2011.

Severn Trent Water (2011), *Climate Change Adaptation Report: A Response to the Climate Change Act's Adaptation Reporting Power*, www.stwater.co.uk/upload/pdf/Climate_Change_Adaption_Report_Executive_Summary.pdf, accessed 4 October 2011

SIPPEREC (Syndicat Intercommunal de la Périphérie de Paris pour l'Électricité de les Réseaux de Communication) (2009), *Rapport d'Activité 2009*, www.sipperec.fr/fileadmin/templates/pdf/rapport_activite/Rapport_d_activite_Sipperec_2009.pdf, accessed 11 August 2011.

Sompo Japan (2010), *Weather Index Insurance Launched for Drought Risk in Northeast Thailand*, www.sompo-japan.co.jp/english/about/csr/topics/20100125_1.html, accessed 11 August 2011.

Sompo Japan (2011), *Applications for Weather Index Insurance for Thai Farmers- Expansion of Sales Area to Five Provinces Increase Number of Insurances Sold to 6,173*, www.sompo-japan.co.jp/english/about/csr/topics/e_20110719.html, accessed 11 August 2011.

SWCCIP (South West Climate Change Impacts Partnership) (2008), *Business Adaptation Case Studies*, www.oursouthwest.com/climate/registry/adaptation-business-case-studies2007-08.pdf, accessed 11 August 2011.

UNEP FI (United Nations Environment Program Finance Initiative) (2011), *Advancing adaptation through climate information services: Results of a global survey on the information requirements of the financial sector*, UNEP FI, Geneva, www.unepfi.org/fileadmin/documents/advancing_adaptation.pdf, accessed 12 August 2011.

UNFCCC (United Nations Framework Convention on Climate Change) (2002), "Decision 28/CP.7: Guidelines for the preparation of national adaptation programmes of action" in *Report of the Conference of the Parties on its Seventh Session, Held at Marrakesh from 29 October to 10 November 2001: Addendum – Part Two: Actions Taken by the Conference of the Parties*

(FCCC/CP/2001/13/Add.4), pp.7-13, http://unfccc.int/resource/docs/cop7/13a04.pdf#page=7, accessed 11 August 2011.

Veolia Environnement (2007), *Sustainable Development Report 2007*, www.veolia.com/en/medias/publications/?cats=1&page=2, accessed 11 August 2011.

Veolia Environnement (2008), *Proposals for responsible management of environmental services*, www.veolia.com/veolia/ressources/files/2/8851,1937,080312VEOLIA1233_DD_UK.pdf, accessed 11 August 2011.

Veolia Water South East (2011), *Adapting to Climate Change: A report to Defra and the Secretary of State in response to a direction to report under the Climate Change Act 2008*, http://archive.defra.gov.uk/environment/climate/documents/water-comp-adapt-plan/wc-veolia-south-east.pdf, accessed 11 August 2011.

WBCSD (World Business Council for Sustainable Development) (2008), *Adaptation: An issue brief for Business*, WBCSD, Geneva, www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=MzA5ODk, accessed 12 August 2011.

ANNEX 1: BUSINESS SECTORS AND SUB-SECTORS

Goods producing sectors	**Manufacturers** produce products, from raw materials or component parts, which they then sell at a profit. Companies that make physical goods, such as cars or pipes, are considered manufacturers.
	Agriculture and mining businesses are concerned with the production and exploitation of raw material, such as plants or minerals.
Goods and services providing sectors	**Retailers and Distributors** act as middle-men in getting goods produced by manufacturers to the intended consumer, generating a profit as a result of providing sales or distribution services. Most consumer-oriented stores and catalogue companies are distributors or retailers.
	Transportation businesses deliver goods and individuals from location to location, generating a profit on the transportation costs.
	Utilities produce public services, such as heat, electricity, water distribution or sewage treatment, and are often government chartered.
Service providing sectors	**Financial businesses** include banks and other companies that generate profit through investment and management of capital.
	Information businesses generate profits primarily from the resale of intellectual property and include movie studios, publishers and packaged software companies.
	Real estate businesses generate profit from the selling, renting, and development of properties, homes, and buildings.
	Other service businesses offer intangible goods or services and typically generate a profit by charging for labour or other services provided to government, other businesses or consumers (e.g. house decorators, consulting firms, restaurants, entertainers, etc.).

ANNEX 2: COMPANIES INTERVIEWED FOR THE ANALYSIS

Sector		Company	Location
Goods	Manufacturers	BASF	Headquarters in Germany, operating in more than 80 countries
		Bayer	Headquarters in Germany, operating worldwide
		BG Group	Headquarters in UK, operating in more than 25 countries
		Shell	Headquarters in the Netherlands, operating in more than 90 countries
		Unilever	Headquarters in UK and the Netherlands, operating in 180 countries worldwide
	Metals and mining	AngloGold Ashanti	Headquarters in South Africa, operating additionally in Ghana, Mali, Australia, Brazil, Tanzania, USA, Guinea, Argentina and Namibia
		Rio Tinto	Headquarters in UK and Australia, operating all over the world
Goods and services	Retailers and Distributors	Carrefour group	Headquarters in France; operating in Europe, Latin America and Asia; pioneering entrant in Brazil and China
	Utilities	Anglian Water	UK
		EDF	Headquarters in France, operating in Europe, North America and Asia
		Entergy	United States
		GDF SUEZ	France
		Réseau de Transport d'Electricité (RTE)	France
		Veolia	France, operating in 74 countries
Services	Other service businesses	PricewaterhouseCoopers	Headquarters in the UK, operating in 154 countries
		Etudes et Projets Industriels (EPI)	France

ANNEX 3: ADDITIONAL ADAPTATION EXAMPLES

Sector		Company	Location
Goods	Manufacturers	Malmesbury Syrups	UK
		Monsanto	Headquarters in the United States, operating worldwide
		Syngenta	Headquarters in Switzerland, operating in 86 countries
	Metals and mining	Rio Tinto Alcan	Canada
Goods and services	Utilities	Severn Trent Water	UK
Services	Financial businesses	Aviva	Headquarters in UK, operating in 28 countries
		AXA	Headquarters in France, operating worldwide
		Bank for Agriculture and Agricultural Co-operatives (BAAC)	Thailand
		Lloyd's	Headquarters in UK, operating worldwide with regional offices in 31 further countries
		Munich Re	Headquarters in Germany, operating worldwide
		Sompo Japan Thailand	Thailand
		Swiss Re	Headquarters in Switzerland, regional offices in 24 further countries
	Information Businesses	Google	Headquarters in the United States, operating worldwide