BUSINESS

WEATHERING THE STORM: BUILDING BUSINESS RESILIENCE TO CLIMATE CHANGE

CENTER FOR CLIMATE
AND ENERGY SOLUTIONS

Project Director

Janet Peace
Center for Climate and Energy Solutions

Report Authors

Meg Crawford
Stephen Seidel
Center for Climate and Energy Solutions

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The Center for Climate and Energy Solutions (C2ES) is an independent, nonprofit, nonpartisan organization promoting strong policy and action to address the twin challenges of energy and climate change. Launched in November 2011, C2ES is the successor to the Pew Center on Global Climate Change. Learn more at www.C2ES.org.

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FOREWORD

Eileen Claussen, President, Center for Climate and Energy Solutions
Alexandra Liftman, Global Environmental Executive, Bank of America

The recent increase in costly extreme weather events has provided a clear signal to many companies of the near-term risks associated with climate change. Extreme droughts in the U.S. Midwest, severe heat waves in Europe, damaging floods in Thailand, and destructive storms along the east and west coasts of Australia and the Northeast United States—these are just a few of the extraordinary events over the past three years that foreshadow the challenges to come under changing climate conditions.

There is compelling evidence that the risks of costly extreme weather events are on the rise. A 2011 report by the New York State Energy Research and Development Authority warned that the combination of sea level rise and coastal surge that can accompany a powerful storm could flood many of New York City's major infrastructures, and estimated that the economic losses from a 100-year storm could range from $58 billion to $84 billion.[1] The estimated $65 billion in damages[2] from "Superstorm" Sandy, which overwhelmed the city in October 2012, falls directly within that range.

These experiences call into question current assumptions about weather risk and preparedness, and call for much stronger responses by businesses—and governments. Many companies are asking themselves whether they have entered a "new normal," and which steps they should take—and when—to build resilience to these increased risks.

Yet there is uncertainty regarding the precise nature and timing of changes in climate and extreme weather risks. Understanding the likelihood or severity of impacts remains a significant barrier for companies deciding how and when to invest in resilience beyond "business as usual." As a result, business activities to build resilience are largely a continuation of existing practices and policies that are based on a historical picture of past risks, and often fail to sufficiently consider changing climate and weather conditions. Thus, the most common strategy for addressing climate-related risks leaves most companies without the resilience they need to weather future physical impacts of climate change.

A few leading companies are taking steps to address climate risks where there is a clear business case to do so. This report explores effective methods used by leading companies to build greater resilience into their operations, supply chains, preparedness policies, and risk management plans. The strategies of the companies studied share certain key actions:

- ***Build Awareness.*** Companies are beginning now to build a common base of understanding of the risks associated with extreme weather and impacts of climate change, and of their potential effects on operations, facilities, supply chains, employees, customers, and communities.
- ***Assess Vulnerabilities.*** Companies are building on existing business risk assessment activities to identify how changes in the likelihood or magnitude of extreme weather events may affect their business.
- ***Manage Risks and Pursue Opportunities.*** Companies are prioritizing options and measures to take, and integrating them into enterprise-wide risk management systems. It is important that companies work across their value chain, and with local governments and stakeholders, to ensure that actions taken will build in an appropriate level of resilience.
- ***Assessment and Review.*** Leading companies, by incorporating the risks of physical impacts into ongoing risk management activities, are periodically updating their understanding of the risks and their responses as new information becomes available, and are laying the groundwork for learning and developing resilience strategies and capacities over time.

These companies are taking action largely without government mandates. Their efforts are driven instead by what they see as significant opportunities to become a more efficient business, to manage critical short- and long-term risks to the company, to reduce costs, and provide greater value to customers. While uncertainties exist about precisely *how* climate change will manifest over the coming years and decades, leading companies are recognizing that, given the already substantial risks associated with the full range of projected climate change impacts, waiting to act can be a costly response.

ACKNOWLEDGMENTS

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EXECUTIVE SUMMARY

Economic damages from weather-related disasters climbed to near-record levels in 2012, with over 800 major events worldwide causing an estimated $130 billion in losses. Munich Re reported that it was the third-costliest year on record behind 2011 and 2005. Many of the most costly events occurred in the United States, including the devastation caused by Superstorm Sandy and the widespread, prolonged drought in the Midwest.[3] Companies and their stakeholders—governments, employees, communities and customers—are increasingly concerned about the costs associated with more frequent and intense floods, droughts, hurricanes and wildfires. Many companies are taking steps to begin to enhance their resilience to these growing risks. However, companies traditionally have planned based on past weather events, and few have attempted to integrate the increasing risks associated with the changing climate into their planning and operations. Initial efforts to do so suggest that barriers and uncertainties often stand in the way, preventing companies from achieving resilience against the rising risks of climate change impacts.

This report, *Weathering the Storm,* provides an in-depth look at the ways multinational companies are beginning to assess and address the risks of extreme weather and other climate change impacts. The companies examined play strategic roles in the global economy in a wide range of sectors including banking and financial services, consumer goods, healthcare, information communications, manufacturing, and materials. The report is based on two complementary lines of research:

- A comprehensive review of the perspectives and activities of companies listed in the Standard and Poor's (S&P) Global 100 Index, based on their reporting to the Carbon Disclosure Project and in their corporate sustainability reports and annual financial filings; and
- In-depth case studies of the practices and experiences of six companies in diverse sectors: American Water, Bayer, The Hartford Group, National Grid, Rio Tinto and Weyerhaeuser.

Together, these sources provide a detailed snapshot of the state of resilience planning among a cross-section of global companies: how they perceive and talk publicly about their climate-related risks, the steps they are taking or planning to take, and the barriers that stand in their way. The research in this report also establishes a baseline that can be used to monitor risk management activities related to climate impacts over time.

Broadly speaking, the research reveals that while the vast majority of companies recognize risks from extreme weather and climate change, and many see these risks in the present or near term, uncertainty about the precise nature, timing and severity of climate impacts often inhibits investment in resilience beyond "business as usual." A few leading companies are taking steps to address climate risks where they see significant opportunities to become more efficient, reduce costs, or provide greater value to customers—in other words, where there is a clear business case to do so. By and large, however, the business response thus far is largely a continuation of existing practices based on a historical picture of past risks, and often fails to adequately consider changing climate and weather conditions. Thus, the most common strategy for addressing climate-related risks leaves most companies without the resilience they need to weather future physical impacts of climate change.

Beyond these broad conclusions, the report outlines a set of more detailed findings on prevailing attitudes and practices among S&P Global 100 companies. And, to help encourage and inform stronger resilience efforts, it lays out a four-step framework for managing climate risks that incorporates the emerging best practices from case-study companies already working to prepare for the very likely prospect of increasing extreme weather and climate change impacts.

KEY FINDINGS

Companies widely acknowledge risks from extreme weather and climate change, but estimates of significance vary

Ninety percent of the S&P Global 100 Index companies identify extreme weather and climate change (such as warmer temperatures, more extreme weather, or greater water scarcity) as current or future risks to their business, across all industry sectors. Most of the S&P Global 100 companies (82), and all of the case-study companies, discussed these concerns in their response to the Carbon Disclosure Project (which specifically includes questions on this topic). Substantially fewer addressed extreme weather and climate change in either their financial filings (36 companies) or their annual sustainability reports (35 companies). The limited mention of climate change impacts outside of the Carbon Disclosure Project responses suggests that this issue has not yet risen to the level of financial materiality or public significance for the vast majority of companies included in the research.

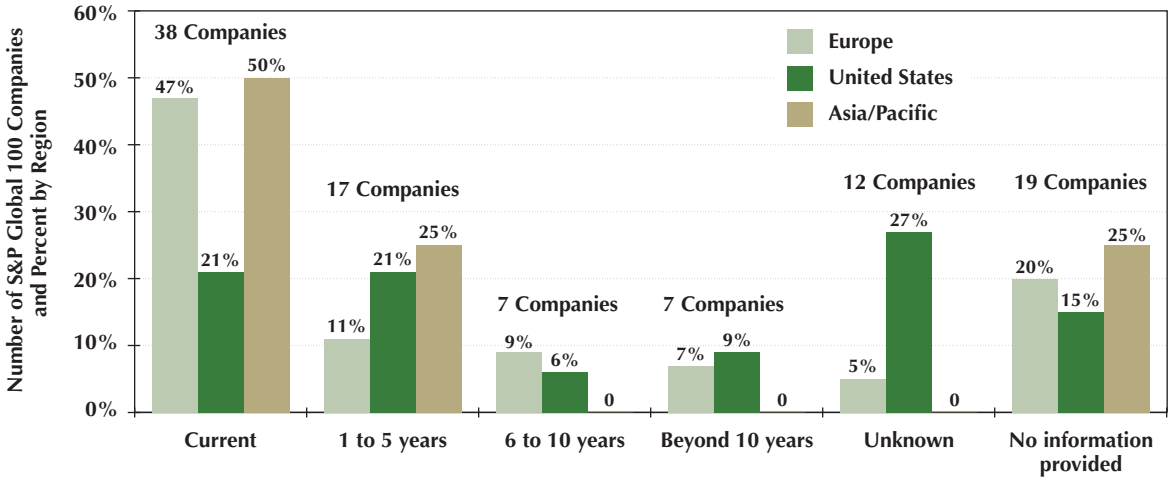
Of the ten S&P Global 100 companies that do not acknowledge risks from extreme weather and climate change in any of the three sources of public disclosure reviewed, six are in the manufacturing & industrials sector, three are consumer goods companies, and one was in the healthcare sector. Among these ten companies, five have assessed the risks of extreme weather and climate change and concluded that such risks would not generate a substantive change in expenses or revenues. The remaining five companies are silent on the subject.

Yet while the vast majority of companies acknowledge risks from extreme weather and climate change, they also describe challenges with adequately understanding the risks and their implications for the business. Several, for example, describe the risks as relatively minimal, too distant in time to be of concern, too difficult to quantify, or too uncertain to support business decisions directed specifically at improving their resilience. Several case-study companies describe challenges with communicating internally with decision-makers about climate-related risks that are inherently volatile and uncertain.

Most companies have experienced extreme weather and climate change impacts or expect to within five years

Many companies are already experiencing climate change impacts or expect to in the near future. Nearly all case-study companies say that they are experiencing a greater intensity and variability of extreme weather than they did in the past. Over one-third (38) of S&P Global 100 companies report that they have already experienced the adverse effects of extreme weather and climate change, and an additional 17 companies believe that such impacts will affect them in the next five years (**Figure ES-1**). Fewer companies—fourteen—believe that such impacts are at least five or

FIGURE ES-1: Earliest Estimates for When Impacts Will Occur



Source: C2ES research based on Carbon Disclosure Project and other information sources (2012).

ten years away. Given the recent extreme weather events in Thailand (extensive flooding in 2011), Australia (heatwaves, floods, drought and wildfires in 2010–2013) and Europe (heatwaves and droughts in 2010–2011), a relatively greater percentage of S&P Global 100 companies headquartered in the Asia/Pacific (50 percent) and Europe (47 percent) regions reported that they have already experienced the effects of such events. Only 21 percent of U.S. companies indicated they had similar experiences.

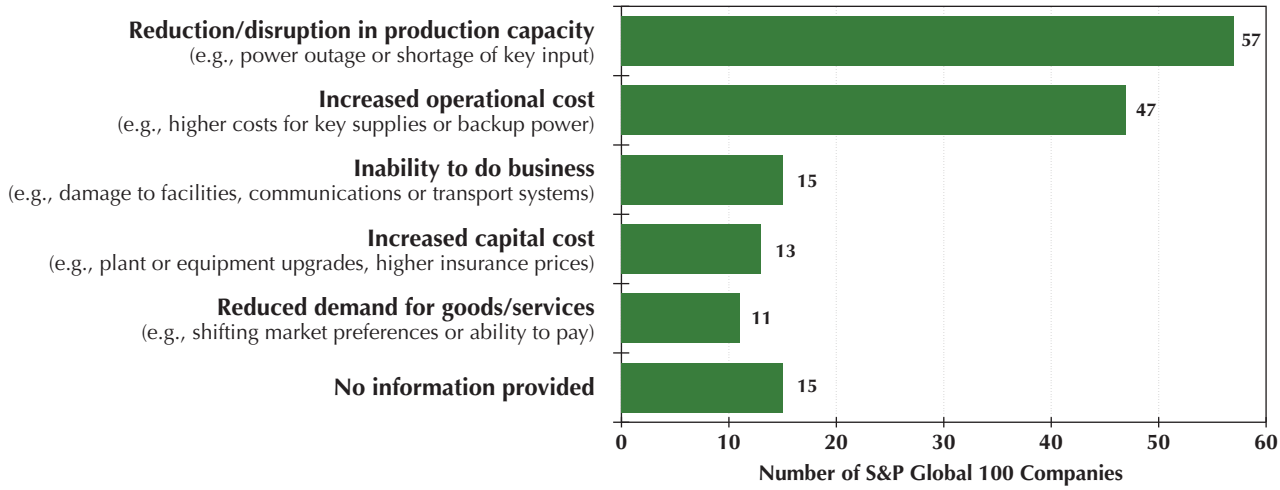
While climate change is often characterized as a long-term, multi-generational problem, its potential to increase the near-term risks of some types of extreme weather events (e.g., droughts, wildfires, extreme precipitation, coastal flooding) is shifting forward the timeframe of concern for business. Companies are wondering whether they have entered a "new normal" of increasing frequency and magnitude of extreme weather events. Most case-study companies say that the recent increase in costly extreme weather events has provided a clear signal of the near-term risks associated with climate change. While relatively few companies are concerned about the possible impacts from the gradual, long-term rise in temperatures or sea level, more are concerned about increased near-term risks to operations, logistics, or supply chains from increasingly damaging extreme weather events.

Yet scientific assessments have only recently begun to take a close look at the changes in extreme weather that would accompany climate change. In 2012, for example, the Intergovernmental Panel on Climate Change (IPCC) released a special report focusing on extreme weather events.[4] In the United States, the National Climate Assessment is working toward issuing its final report in 2013, which will include extensive discussion related to extreme events and their impacts across the country.[5]

Disruptions to operations and production capacity are of greatest concern

The top two areas of concern identified by S&P Global 100 companies are direct impacts on production capacity such as property damage or supply interruptions (mentioned by 57 companies) and impacts on operational costs such as higher commodity prices or maintenance costs (47 companies) (**Figure ES-2**). Examples include concerns about the availability of water for manufacturing processes or potential impacts on critical inputs and supply chains. Concerns about disruption to production or increases to operational costs are cited by a majority of all sectors, except banking & financial services. Far fewer companies express concerns about indirect impacts on their business, such as increased capital costs (13 companies) or the effects on customers (11 companies). Several case-study companies also note how climate change can amplify the effects of other stresses caused by increasing populations, migration, urbanization, or coastal development.

FIGURE ES-2: Top Five Current or Expected Impacts from a Changing Climate



Source: C2ES research based on Carbon Disclosure Project and other information sources (2012).

Companies also have experienced a number of important external risks that they cannot directly manage but that can significantly affect the bottom line. For example, extreme weather events can impact the ability of employees to get to work, disrupt transportation and communication systems, and threaten the availability of energy or other raw materials. Because many of these hazards fall squarely within the control of other entities such as local governments or utilities, companies cannot take direct action to enhance their resilience to these risks, but can seek to indirectly mitigate their impacts by updating their business continuity or emergency preparedness plans so that they specify, for example, the provision of back-up power or arrangements for alternative modes of transportation.

Supply chains may be a particular source of business vulnerability

Companies are learning first-hand that even when their own risk assessments take climate change impacts into account, their operations can still be severely damaged if their suppliers have not taken the same steps. A significant number—40 percent—of S&P Global 100 companies highlight current or potential future risks to their supply chains from extreme weather and climate change. Over half (25) of these 40 companies, primarily in the consumer goods, healthcare, and information and communications technologies (ICT) & services sectors, are concerned about interruptions across their global value chain, specifically, damage to suppliers of key inputs, transport difficulty for intermediate goods, or supply disruptions for getting final products to market. Eighteen companies are also particularly concerned about the availability and quality of water supply. To address these risks, some companies have taken steps to work with their suppliers to ensure they have their own plans to minimize the adverse impacts from extreme weather events. Other companies look to further geographically diversify their sources of supply or bring more of their supply chain closer to home operations.

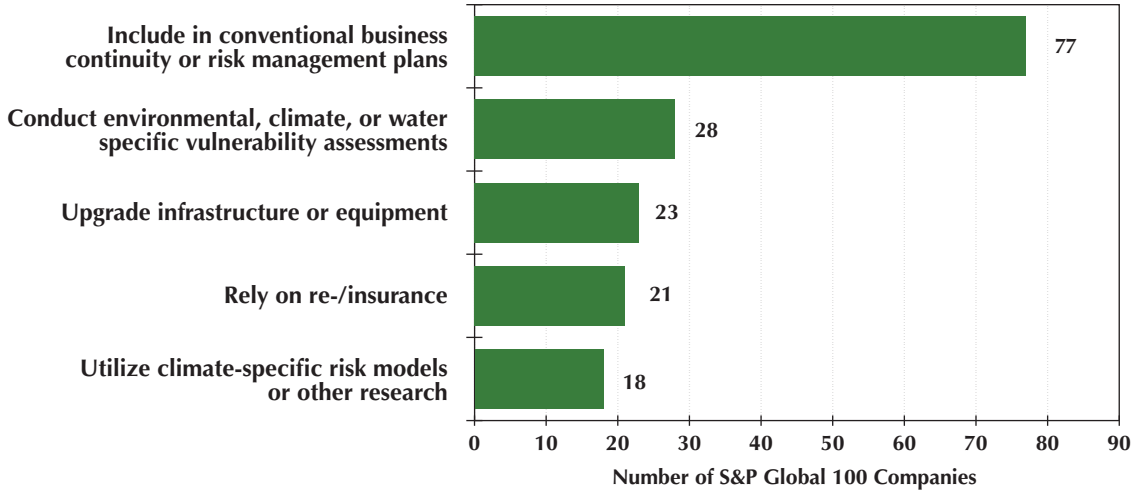
Companies see potential market opportunities resulting from a changing climate

For most companies, climate change impacts do not only mean increasing risks. Businesses across all sectors are identifying a wide range of products and services that meet new and expanding market demand in a world faced with increased risks and impacts of extreme weather. Most of S&P Global 100 companies (75 percent) identified potential market opportunities resulting from a changing climate. Drought- and salinity-resistant crops, technologies that enhance water use efficiency, weather-related insurance products, enhanced land management techniques, and storm-resistant building materials are just a few examples of the market opportunities that companies have identified. The largest number of companies (37) identified expanding markets for existing products and services as the most promising opportunities for business and revenue growth. Twenty-seven companies (mostly in the banking & financial services sector) identified opportunities for new products and 16 companies described opportunities to reduce operational costs (e.g., energy or insurance costs) associated with extreme weather impacts. Companies in the manufacturing & industrials and consumer goods sectors were the least likely to identify new opportunities.

Companies rely heavily on existing enterprise risk management approaches that may underestimate climate risks

For most companies, physical climate impacts are managed as a conventional business continuity or enterprise risk management issue. Most companies already have well-established business continuity and emergency management plans to minimize damage from extreme weather and speed recovery from such events. The majority of S&P Global 100 companies (77) report that changes in extreme weather risks due to climate change are incorporated into their existing business continuity plans and processes (**Figure ES-3**). Case-study companies explain that extreme weather impacts—power outages, property damage, or water shortages—are types of risks that they are already prepared to mitigate through plans that ensure safety, provide for operational continuity, and meet obligations to customers, and which can be readily adapted if weather extremes were to increase in the future. But while business continuity and risk management plans can be effective corporate planning tools for dealing with extreme weather events, most companies will need to adjust how they use these tools to reflect the changing profile of climate-related risks. Future events are likely to be similar in type (e.g., droughts, storms, etc.), but occur more frequently or be more intense.

FIGURE ES-3: Top Five Climate Risk Management Activities



Source: C2ES Research (2012).

In developing or updating their business continuity and emergency preparedness plans, companies struggle with what to assume about the changing risk profile of extreme weather. Some underestimate future risks by simply assuming that past events will be repeated in the future, or use historical trends and factor in a "margin of safety" (e.g., a 100-year event will become a 50-year event). Others look to climate assessments (e.g., typically scenarios contained in the Intergovernmental Panel on Climate Change assessments), but the scale of these assessments tends to be too large to be useful for companies evaluating individual facilities and they are only undertaken every five to seven years. Companies need more user-friendly, more readily accessible, and finer-grained information on future climate risks.

Relatively few companies have undertaken comprehensive climate vulnerability assessments

A small number of S&P Global 100 companies have undertaken climate-related vulnerability assessments (28 percent) or used climate-specific tools or models (18 percent) to more comprehensively assess risks. Those companies that have undertaken more detailed vulnerability assessments of operations or supply chains are generally those that have the most at risk: companies most dependent on the long-term availability of a key commodity or natural resource, those with operations in high-risk locations such as drought- or flood-prone locations, those with direct financial interests (e.g., banking and insurance), and those with operations in rapidly changing environments (e.g., Alaska and the Arctic). All of the case-study companies have worked directly with scientists and researchers from government agencies or universities in order to supplement their enterprise risk management strategies with data that informs sensitivity analyses and guidance for decision-making. While companies have found these detailed assessments extremely useful in building resilience, they also acknowledge the substantial costs and challenges in finding accessible, user-friendly data and the lack of appropriate analytical tools. For help in better understanding their vulnerabilities, companies have reached out to universities or government experts, worked with their insurance companies, or enlisted consultants.

Uncertainty about climate change impacts and the limited availability of high-quality risk data are significant barriers to action

The uncertainty associated with the nature, timing, location, and/or severity of climate change poses a challenge for deciding how and when to invest in resilience beyond "business as usual." This uncertainty is cited as a critical issue

by nearly one-quarter (24) of S&P Global 100 companies and by all of the case-study companies. Many companies often also lack in-house knowledge or expertise about extreme weather and climate change; lack accessible, user-friendly localized projections of future changes in climate; need models and tools that link projected changes in climate to impacts germane to company operations; and have a lingering perception that climate change is too uncertain and long-term an issue to require near-term action. Some types of changes, like average annual temperature or sea level rise, may be more readily accessible on a global scale but may mask less transparent but potentially more damaging changes from episodic heat waves or floods. Companies identified the need for a centralized information clearinghouse to provide a single go-to place for reliable, up-to-date data and analytical tools in order to reduce their uncertainty and support their efforts to enhance their resilience. Case-study companies emphasized that, absent sufficient certainty about the nature and timing of expected impacts, decisions related to building resilience ultimately balance a variety of business factors, such as equipment condition and age, the company's ability to meet future regulations, or opportunities to improve efficiencies.

Governments play an important role in facilitating resilience efforts

Companies face significant barriers when making decisions about how and when to invest in enhancing their resilience to climate change. While overcoming these barriers is largely an internal challenge, case-study companies note that there are a number of steps that governments can take to facilitate these corporate efforts. They can support and coordinate efforts around climate change research, enhance the resilience to weather extremes of critical public infrastructure, and advance and approve resilience planning in regulated sectors such as water, electricity, and insurance.

A Framework for Managing Climate Risks: Emerging Best Practices

Based on the experiences of case-study companies that are working proactively to better understand and manage climate change risks, it is possible to identify a set of emerging best practices. Generally, these companies follow a four-step process (**Figure ES-4**): they collect information and build knowledge about the growing risks; assess and prioritize them using corporate risk management frameworks; develop plans and guidance that inform management decisions; and incorporate risk factors into an ongoing, iterative review process.

In many ways, building resilience is doing what companies have always done—strategic planning, risk assessment, investing in infrastructure, diversifying the supply chain, safeguarding employees—using the best information available about potential risks. Leading companies are preparing to capture the competitive advantages that accrue from more effectively managing these risks, speci!cally by expanding their risk management practices to include the fairly new, very real, very serious risks that accompany climate change. They are starting now to collect information and build platforms for increased awareness. They are building adaptive capacity—developing skills, collecting information, and evaluating management options—that will position them to learn and adapt in the long term, and to thrive in a world beset by the unpredictability of a changing climate.

FIGURE ES-4: Four Steps for Managing Climate Risks

1 BUILD AWARENESS

A critical foundation for companies taking concrete steps to enhance their resilience is building a clear understanding of the risks associated with extreme weather and climate change.

This effort should reach out broadly across the company to include all people who must be part of an effective response, including senior managers at headquarters, facility managers in the field, enterprise risk managers, and supply chain planners. It should engage all employees and communities that play an important part of planning and response strategies. This outreach effort should address the common misperception that future conditions will be similar to those experienced in the past, and should make clear that climate change is increasing the risks of certain types of extreme weather events and these risks may have significant impacts on the company's bottom line.

2 ASSESS VULNERABILITIES

Companies can build on existing business risks assessment activities to identify the impacts that future changes in the likelihood or magnitude of extreme weather events could have on their operations and facilities.

There is no one single best approach for undertaking such a vulnerability assessment; the research identified a variety of ways of analyzing these changing risks based on the degree of internal expertise and the magnitude of risks. Whatever the particular approach selected, a vulnerability assessment would benefit from including the following considerations:

- A high-level initial screening of potential climate risks across the company, with more in-depth vulnerability assessments of high-risk facilities and operations;
- Forward-looking assumptions about changes in the risk profile of extreme weather and climate change; and
- Information about changes in related factors (e.g., land use, population growth, competition for scarce resources) that could also amplify or alter risks.

3 MANAGE RISKS AND PURSUE OPPORTUNITIES

Once potential impacts are identified, companies must develop plans to prioritize actions to manage these risks and maximize opportunities.

It is critical that companies work across their value chain, and with local governments and stakeholders, to ensure that actions taken will build in an appropriate level of resilience. Specific risk mitigation actions could include:

- Modifying planning and operations;
- Fortifying or relocating infrastructure and facilities;
- Addressing volatility or changes in the supply of key commodities such as water;
- Managing risks within supply chains; and
- Expanding or adjusting insurance coverage.

In better managing the risks of future extreme weather, leading companies have also identified a range opportunities to offer new services or products better suited to a world experiencing more frequent or intense extreme weather.

4 ASSESSMENT AND REVIEW

Leading companies, recognizing that the risks of extreme weather and climate change will evolve over time, are beginning today to develop adaptive risk management planning.

They periodically update their understanding of risks and their responses as new information becomes available and they are fine tuning their resilience strategies and capacities over time.

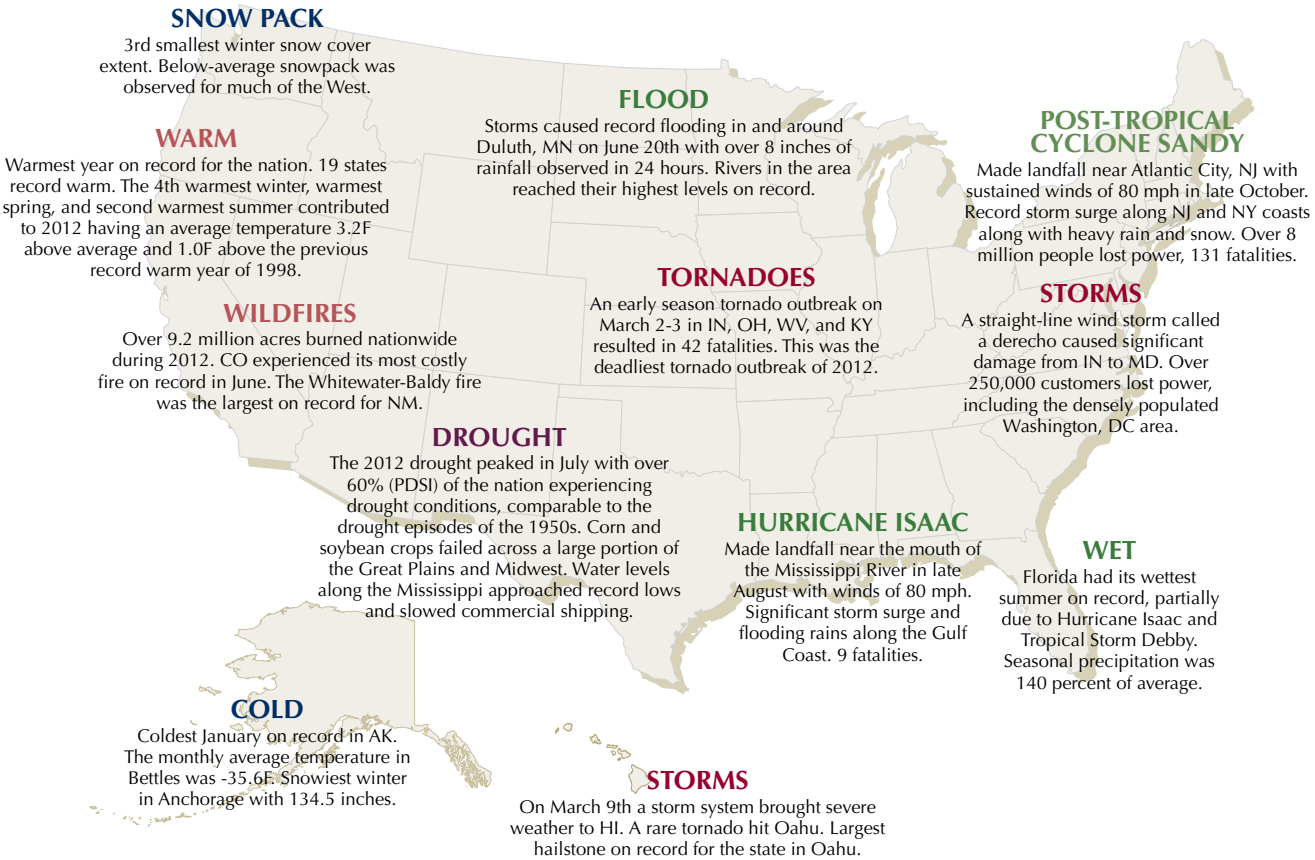
I. INTRODUCTION

Climate change has long been on the radar screen of global businesses. However, until recently most companies have focused on reducing their greenhouse gas emissions, and only in the past few years have they begun to recognize that they must also adapt to the physical impacts of climate change. In addition to their efforts to mitigate climate change, they need to increase their resilience in the face of increased risks associated with the now-unavoidable physical impacts, including higher temperatures, rising sea levels, changing availability of water, and extreme weather.

THE BUSINESS CONTEXT FOR BUILDING RESILIENCE TO CLIMATE CHANGE

Bottom-line costs. The recent increase in costly extreme weather events has provided a clear signal to many companies of the near-term risks associated with climate change. While companies have always needed to manage weather-related risks, many are now experiencing a greater intensity and variability of extreme weather events than they did in the past. The year 2012 brought extreme weather events to all regions of the United States **(Figure 1)**. The most costly 11 weather-related

FIGURE 1: Significant U.S. Weather and Climate Events, 2012



PDSI is the Palmer Drought Severity Index, a measurement of dryness based on recent precipitation and temperature. Among the impacts in Figure 1, an increase in tornadoes is not linked to climate change.

Source: NOAA's National Climatic Data Center (2013).[6]

events in 2012 each resulted in economic losses of $1 billion or more, totaling $110 billion; in 2011, 14 events each exceeded $1 billion in damages.[7] While not all types of extreme weather can be linked to climate change, and no single weather event can be said to be "caused" solely by climate change, there is compelling evidence that higher levels of greenhouse gases in the atmosphere are increasing the frequency of costly disruptive events such as droughts, heat waves, heavy rainfall, coastal flooding, and intense storms. (See Appendix B for a more extended discussion of the role played by climate change in amplifying the risk of certain types of extreme weather.)

Worldwide, the economic damages from weather-related disasters climbed to near record levels in 2012, with over 800 major events causing an estimated $130 billion in losses.[8] A single event—extensive flooding in Thailand in 2011—badly damaged global suppliers of parts for the automotive and electronic industries, hurting the bottom lines of Ford, Honda, Toyota, Dell, Cisco, and many other companies. Direct losses from the floods were estimated at $15 to 20 billion (**Table 1**).[9] These recent experiences highlight how easily current assumptions about weather risk can be overwhelmed by unexpected events, calling into question a company's current planning and response strategies and showing the need for strategies centered around climate resilience.

> ***"[T]he private sector is getting the message that they are vulnerable to severe weather impacts. People see their supply chains are vulnerable to climate impacts. [Companies] see this as something that's in their interest to address."***
>
> —Mark Way, Head, Sustainability Americas, Director, Group Risk Management, Swiss Re[10]

External pressures. A number of external influences are also driving companies to examine their resilience to the impacts of extreme weather and climate change, and to consider ways to make their planning and response strategies robust enough to protect their operations and assets in an era of growing climate instability.

> ***"Sooner or later all businesses will have to climate-proof their operations. Adaptation will be imperative if businesses want to avoid climate-change impacts that could drive them out of business."***
>
> —Christiana Figueres, Executive Director, United Nations Framework Convention on Climate Change[11]

- **Financial Disclosure Rules.** In February 2010 the U.S. Securities and Exchange Commission issued new guidance clarifying that, under existing legal requirements, the physical risks from climate change must be disclosed by listed companies where such risks have a "material" impact on a company's financial situation (information that a reasonable shareholder would consider important to know). The guidance specifically cites the need to consider such physical effects as "increases in storm intensity, sea level rise, thawing permafrost, temperature extremes, changes in the availability or quality of water or other natural resources, floods, and decreased agricultural production capacity."[12] Climate change-related disclosure rules or guidelines are also in place for companies listed on exchanges in Australia, Denmark, South Africa, Sweden, and the United Kingdom.
- **Investor Pressure for Action.** Interest among investors for the disclosure of physical climate change risks continues to grow. The number of shareholder resolutions filed with public companies in the U.S. and Canada on issues related to climate change impacts and adaptation nearly doubled in a single year, from 2010 to 2011.[13] The Global Framework for Climate Risk Disclosure, released in 2006 as guidance from institutional investors to companies reporting on climate change, calls on companies to analyze and disclose the "material, physical effects that climate change may have on the company's business and its operations, including their supply chain." It also calls on companies to report on how they could adapt to such changes and estimate the potential costs of such adaptations.[14] In 2006, the Carbon Disclosure Project expanded its annual survey of companies, on behalf of 722 institutional investors holding $87 trillion in assets, to include more explicit questions about the physical risks from climate change, and in 2009 it launched a water risk disclosure initiative.

TABLE 1: Costs of Recent Extreme Weather Events

SECTOR	IMPACTS
Insurance	**Munich Re** received claims worth more than $350 million from severe flooding in Australia in 2010-2011, contributing to a 38 percent decline in quarterly profits.[15] In 2011, property and casualty insurer **The Hartford** paid out $745 million in natural catastrophe claims, more than the combined average catastrophe losses over the previous ten years. The initial estimate for its catastrophe losses in 2012 from "Superstorm" Sandy alone is approximately $370 million.[16]
Manufacturing	Hurricanes Gustav and Ike in 2008 caused temporary outages at several of **Dow Chemical Company's** U.S. Gulf Coast production facilities, resulting in $181 million in additional operating expenses.[17] **Honda** suffered a loss of over $250 million when heavy floods in Thailand inundated automobile assembly plants in 2011.[18] **HP** estimates that more than half of its 7 percent revenue decline in the fourth quarter of 2011 was attributable to a shortage of hard disk drives caused by the flooding in Thailand.[19] **Holcim**, one of the world's leading suppliers of cement and aggregates, was affected by severe flooding in both Thailand and eastern Australia in 2012, resulting in $6.1 to $8.2 million in maintenance costs and lost production, in addition to costs of around $6.1 million from a surge in coal prices due to impacts on Australian coal mines.[20]
Utilities	Record-setting heat in Texas in 2011 forced **Constellation Energy** to buy incremental power at peak prices and led to quarterly earnings reduced by about $0.16 per share.[21] During the summer of 2012, **Dominion Resources** was forced to shutter one of two units at its Millstone nuclear plant because the temperature of the water being drawn from Long Island Sound exceeded its license limits—the first time in the plant's 37-year history that it had to shut down due to excessively warm seawater.[22]
Oil & Gas	**Chevron**, the largest oil and gas producer in the Gulf of Mexico, was significantly affected by Hurricanes Katrina and Rita in 2005. Reduced crude oil and natural gas production, and added costs for repairs and maintenance of both offshore and onshore facilities, resulted in an approximate $1.4 billion loss in the second half of 2006.[23]
Mining	**Anglo American's** copper production for the first half of 2011 was down 8 percent, due in part to severe disruptions to its Collahuasi mine in Chile caused by rainfall four to five times greater than the annual average.[24] In 2011, **Rio Tinto's** Australian operations were hit by cyclones and widespread flooding, leading to a train derailment and $245 million in reduced earnings. Rio Tinto's uranium subsidiary suffered its largest one-day share price drop in more than two years after higher-than-average rainfall flooded pits at a mine and forced it to suspend operations for three months.[25]

- **Emerging Pressure from State Insurance Regulators.** Insurance commissioners in California, New York, and Washington State now require insurance companies to disclose how they will respond to the risks that their businesses and customers face from increasingly severe storms and wildfires, rising sea levels, and other consequences of climate change. The disclosure survey is mandatory for companies writing policies worth more than $300 million nationwide.[26]

PURPOSE AND METHODOLOGY

This report takes an in-depth look at whether and how companies are responding to the increased risks and pressures presented by climate changes and extreme weather risks. It examines how companies perceive and manage these risks as well as potential business opportunities, describes common business practices for evaluating and building resilience to physical impacts **(Box 1)**, and presents a framework for emerging best practices used by leading companies to manage the risks of extreme weather and climate-related impacts. Specifically, it examines:

- the extent to which companies acknowledge risks from the physical impacts of extreme weather and climate change
- drivers motivating companies' actions to build resilience to climate change impacts
- steps taken by companies to assess potential vulnerabilities
- actions undertaken to more effectively manage the risks and maximize any opportunities
- tools and methods used by companies to assess risks and opportunities
- barriers preventing companies from taking more focused and forward-looking action

The research presented in this report utilizes three types of sources:

1. Public statements made by the 100 companies comprising the Standard and Poor's (S&P) Global 100 Index in their responses to the 2011 and 2012 Investor Surveys conducted by the Carbon Disclosure Project, their 2011 annual financial disclosure reports, and their 2011 corporate sustainability reports.
2. Case studies of six companies (American Water, Bayer AG, The Hartford Group, National Grid, Rio Tinto and Weyerhaeuser) that profile these companies' activities related to managing the physical impacts of extreme weather and climate change **(Table 2).**[27]
3. A C2ES workshop on climate resilience held in November 2012.[28] The workshop was a frank discussion of climate impacts, options for risk minimization, and strategies that companies are employing to increase their resilience.

The S&P Global 100 includes large-cap companies whose businesses are global in nature and for which a substantial portion of their operating income, assets, and workforce come from multiple countries (with the exception of those in the electric power sector). (See Appendix A for a complete list of companies in the S&P Global 100 Index.) This cohort of 100 companies was selected because it constitutes a random sample of companies that are large enough to have experience with public reporting about global environmental risks, and are global enough to be exposed to extreme weather risks. These companies were not selected in any way related to their perspectives on climate change. Using this cohort could also help

Box 1. Climate Adaptation vs. Resilience: Does It Matter What It's Called?

"Adaptation" is the term most widely used to describe efforts to minimize the harm caused by the physical impacts of climate change. Under the United Nations Framework Convention on Climate Change, for example, countries support activities in developing countries that reduce vulnerabilities to climate change through a Climate Adaptation Fund. In the United States, C2ES tracks adaptation planning efforts undertaken by nearly 20 U.S. states[29] and adaptation plans being developed by all U.S. federal agencies.[30]

In contrast, most companies prefer to refer to the actions they take to address the risks from extreme weather and climate change as building "resilience." Whereas "adaptation" has a passive connotation, "building resilience" connotes a proactive, strategic effort and is more in line with standard corporate goals of making companies more flexible and resilient to a changing business environment.

Companies also focus more on responding to the effects of "extreme weather" than to "climate change." This framing allows them to look at the *current* risks of extreme weather and to avoid the perceived long-term nature and political debates sometimes associated with "climate change." Whatever terms are used, it is critical that companies recognize that the risks associated with many types of extreme weather are increasing, that they are increasing because of climate change, and that companies' response strategies must incorporate the best scientific information available on the changing nature of these risks.

establish a baseline for company activities over time. The research forming the basis of the case studies allows a more in-depth examination of some key issues, options, and strategies explored by specific companies. (Additional notes on methodology are in Appendix A.)

TABLE 2: Case Studies at a Glance

COMPANY	COMPANY PROFILE	BUSINESS DRIVERS FOR BUILDING RESILIENCE	KEY INITIATIVES	CHALLENGES FOR BUILDING BUSINESS RESILIENCE
AMERICAN WATER	Industry: Water Utilities Headquarters: Voorhees, New Jersey Revenues (2012): $2.7 billion Employees: 6,700	Recognition of the inherent relationship between water provision and climate factors Observation of climate changes and anticipated water supply scarcity Need/desire to stay ahead of regulatory changes Desire to capture new markets for water-saving technologies	Conducting climate change sensitivity analyses of capital planning decisions Building greater redundancies into energy supply and communications systems Developing innovative water management practices and technologies	Insufficient public and private investment in upgrading aging U.S. water infrastructure Justifying investment decisions based solely on climate changes with uncertain future ranges and impacts Lack of enabling U.S. public policies and government incentives
BAYER AG	Industry: Chemicals Headquarters: Leverkusen, Germany Revenues (2012): $39 billion Employees: 112,000	Need to safeguard operational stability and continuity Observation of customers' exposure to climate risks in a number of sectors and regions Corporate commitment to sustainable and more resilient agriculture systems	Developed climate change risk matrix to inform operational and R&D decisions Building awareness and expertise among business units and staff Engaging in research partnerships analyzing climate changes	Communicating internally about climate-related risks that are variable and uncertain Understanding ripple effects on availability, quality, and price of key commodities such as energy and water
THE HARTFORD	Industry: Property & Casualty Insurance Headquarters: Hartford, Connecticut Revenues (2012): $26.4 billion Employees: 20,000	Observation of a rise in costly extreme weather events A need indicated by insurance pricing models for improved risk management Desire to engage effectively with regulators about increased climate risks	Expanded data collection and primary research Careful market expansion Building awareness of challenges among regulators, customers, and stakeholders	"Short-termism" in insurance pricing and absence of U.S. government incentives for business resilience Insufficient climate data and models to assist the incorporation of risk into policies and pricing

TABLE 2: Case Studies at a Glance (continued)

COMPANY	COMPANY PROFILE	BUSINESS DRIVERS FOR BUILDING RESILIENCE	KEY INITIATIVES	CHALLENGES FOR BUILDING BUSINESS RESILIENCE
NATIONAL GRID	Industry: Electric and Gas Utilities Headquarters: London, United Kingdom U.S. Headquarters: Waltham, Massachusetts Revenues (2012): $22.5 billion Employees: 27,000	Recent experience of costly extreme weather events An imperative to manage weather and climate risk to maintain reliability of operations Government requests for disclosure of climate change impacts and resilience activities	Evaluated business resiliency against a "worst case" scenario of climate changes through 2080 in UK Assessing flood risks in key U.S. geographies Prioritizing investments to reduce interruption losses	Justifying investment decisions based solely on climate changes with uncertain future ranges and impacts Historical information insufficient for understanding future climate conditions
RIO TINTO	Industry: Mining & Processing Headquarters: London, United Kingdom Revenues (2012): $15.5 billion Employees: 120,000	Recent experience of costly extreme weather events Need to safeguard operational and supply chain continuity The presence of climate change impacts and resilience in public policy and stakeholder discourse	Developing climate change scenarios and business implications for key regions Engaging in research partnerships that are analyzing climate change impacts Building climate risk awareness and expertise among business units and staff	Developing resiliency plans and responses to be both business- and location-specific Justifying investment decisions based solely on climate changes with uncertain future ranges and impacts Insufficient climate data and models that are translated into business context
WEYERHAEUSER	Industry: Real Estate Investment Trust; Industrial goods Headquarters: Federal Way, Washington Revenues (2012): $6.2 billion Employees: 12,800	An imperative to address weather and climate risk in managing land holdings Observation of changes in climate and models indicating a need for adaptive risk management Commitment to sustainable forestry practices and recognition of impacts from changing climate	Utilizing forecasting models and sensing technologies to detect early indications of climate changes Engaging in research partnerships that are analyzing climate changes Developing more resilient tree species and forest management practices	Historical information insufficient for understanding future climate conditions Developing practices and actions that respond to an even wider range of possible climate changes than in the past

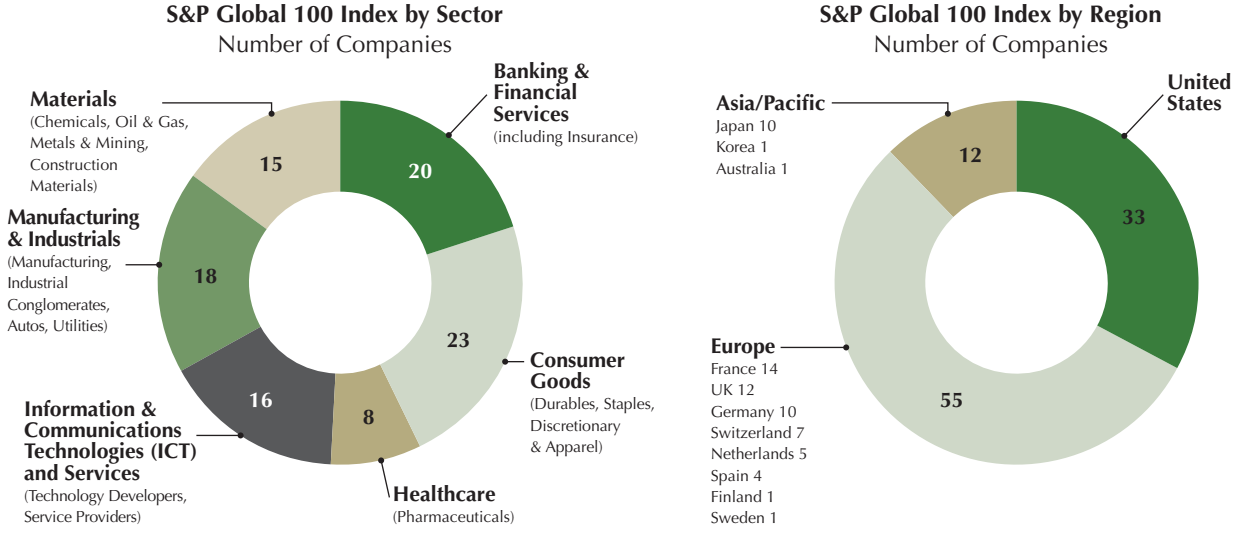
II. BASELINE ASSESSMENT OF CURRENT PERSPECTIVES AND PRACTICES

In order to make a broad assessment of business perspectives and activities related to the risks and opportunities associated with physical climate change, the research analyzed three sources of public statements made by the 100 companies comprising the S&P Global 100 Index: their responses to the 2012 Investor Surveys conducted by the Carbon Disclosure Project, their 2011 annual financial disclosure reports, and their 2012 corporate sustainability reports. The S&P Global 100 Index is composed of 100 large-cap companies representing a wide spectrum of industries and geographies **(Figures 2** and **3)**, companies headquartered in 12 countries, largely from developed regions of the world—Europe, the United States, and Japan. This diversity of sectors and regions allowed for a more detailed analysis of whether certain sectors are leading or falling behind in their efforts to build resilience and whether a company's home country influences actions to address climate change.

Public statements made by companies in the S&P Global 100 Index reveal a number of insights into how large international companies are responding to the risk of physical impacts of extreme weather and climate change. Companies widely apply their established business continuity and disaster response plans to the new challenge of managing climate risks. They use their existing strategies to plan for mitigating disruptions to operations, safeguarding employees, stabilizing supply chains, and quickly recovering from extreme events, considering these frameworks to be adequate for the challenge. These risk management frameworks are a natural first step. Experience with them is often already well developed within the company, they encompass and quantify a wide variety of business risks, and they can be updated to incorporate new and emerging risks and practices.

However, while such frameworks are appropriate tools for managing climate impacts, they often use inaccurate

FIGURES 2 AND 3: A Cross-Sector, Global Cohort of Companies



S&P Global 100 Index on May 30, 2012.
Source: Standard & Poor's (2012).

reference points. These frameworks typically draw from a historical picture of risk and often do not adequately consider the changing character—such as frequency and intensity—of extreme weather events. In only a few cases are companies incorporating more robust and forward-looking assumptions about the increased and evolving risks of extreme weather into their corporate strategies. These examples, though few, provide very useful early lessons and practices for building greater resilience to climate change.

COMPANIES WIDELY ACKNOWLEDGE CLIMATE RISKS, BUT ESTIMATES OF SIGNIFICANCE VARY

Nearly all companies—90 of the 100 companies in the S&P Global 100 Index—acknowledge current or future physical risks driven by changes in climate (such as warmer temperatures, more extreme weather, or greater water scarcity) in at least one of the three sources of public information that we reviewed **(Box 2)**. Companies are far more likely to discuss these impacts and risks in their responses to the Carbon Disclosure Project's survey (82 companies) than in either their financial filings (36 companies) or sustainability reports (35 companies) **(Figure 4)**. Of the 10 companies that did not publicly acknowledge risks from climate change (most of which were in the manufacturing & industrials sector), five explain that the risks had been considered but would not generate substantive damage to the business or a change in current practices. Procter & Gamble, for example, explained that with "approximately 140 manufacturing facilities in 40 countries, ... if we are ... negatively impacted by climate change, we have the flexibility to continue to provide products to the consumer from unaffected facilities. This is part of P&G's Global Business Continuity Program which ensures that all critical sites and work processes evaluate their risk mitigation programs [and] exposure to catastrophic events[.]"[31] The remaining five companies provided no information at all on the issue.

Companies are more willing to discuss climate risks in their voluntary reporting (in the Carbon Disclosure Project (CDP)) than in either their sustainability reports or financial reports. Eighty-two companies acknowledge climate risks in the CDP but only 36 identify risks in their mandatory financial disclosures. It may be that these companies have examined the risks and determined

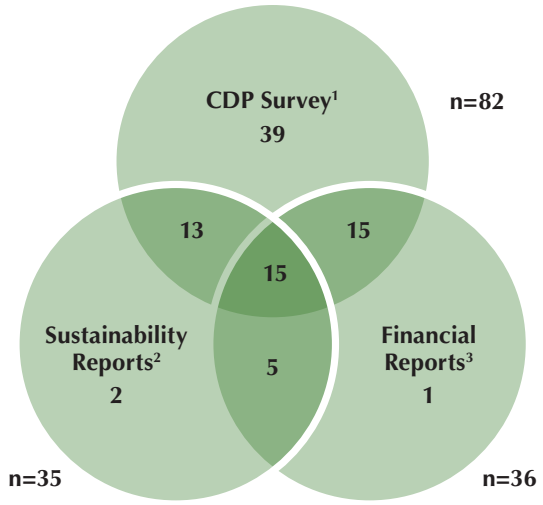
Box 2. Climate Risk as an Enterprise Risk

Many companies address climate risks in the context of their broader enterprise risk management strategies. The specific types of risks most commonly discussed were those related to direct impacts (such as property damage or supply chain interruptions) and indirect impacts (such as increased prices for commodities or insurance). No companies mentioned regulatory, liability, or reputational risks—issues that are often invoked when describing risks from climate change mitigation efforts. Companies are also very concerned with *extremes* in these impacts and associated risks (stronger than average storms or unanticipated severe droughts), rather than slight deviations from the norm.

Enterprise Risks	Example Specific to Climate Change
Hazard risks: liability torts, property damage, natural catastrophe	• Property damage or increasing maintenance costs from floods, hurricanes, droughts
Financial risks: pricing risk, asset risk, currency risk, liquidity risk	• Insurance or business loans that rise in price or become unavailable in flood-prone or coastal areas • Energy or other commodity price shocks or volatility
Operational risks: customer satisfaction, business continuity, product failure, reputational risk	• Changing requirements for equipment or heating and cooling • Changing resource availability and quality (water, power) • Customer obligations not met due to supply interruption
Strategic risks: competition, social trend, capital availability	• Market shifts, reduced product demand • First mover advantage for meeting new market demands • Possible public responses to resource constraints (water access, public health concerns) leading to compliance or regulatory costs

FIGURE 4: Where Companies Report on Physical Impacts of Climate Change

Number of S&P Global 100 Companies



[1] Yes/No answers to Carbon Disclosure Project (CDP) Question 5; out of 94 companies responding

[2] Based on C2ES ranking (see Appendix A); out of 97 company reports

[3] Based on C2ES ranking (see Appendix A); out of 100 company reports

Source: C2ES Research (2012).

that they did not meet the "materiality" requirement for inclusion in their financial reporting (information that a reasonable shareholder would want to know). Even when climate risks are mentioned in financial reports, few companies provide the detail needed to fully inform investors of the risks.[32]

The fact that only a limited number of companies (35) discussed physical climate change impacts in their 2012 sustainability reports may indicate that climate resilience has not yet risen to the same level of importance internally as have climate change mitigation efforts, which remain a key feature in corporate sustainability reports, or may indicate a continuing reluctance among some companies to publicly engage on "adaptation" issues (Box 1, page 4). It may also be due to the fact that while sustainability reports tend to focus on the impacts of business on the environment, resilience is about the impact of the environment on the business.

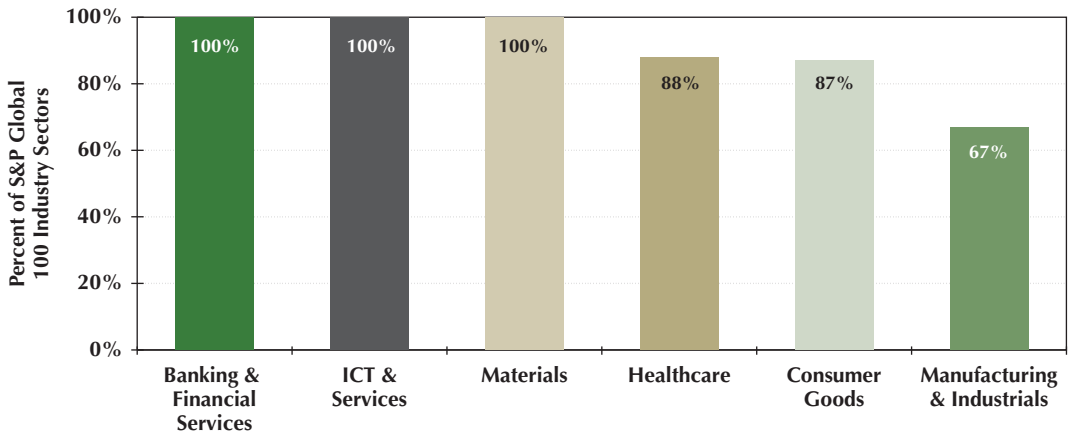
Companies in the manufacturing & industrials sector are least likely to acknowledge physical risks from climate change or extreme weather **(Figure 5)**. In at least some cases, their lack of acknowledgment of risk stems from difficulty with defining the risks specifically enough to increase the company's resilience. Ford Motor Company explains, for example, that "Based on [our] assessment of the physical risks associated with climate change, we do not believe we can adequately predict the potential impacts of climate change on our business beyond noting the risk posed by natural or man-made disasters."[33]

Companies acknowledging risk varied little by the location of their headquarters. Ninety-one percent of companies in Europe, 91 percent of U.S. companies, and 83 percent of Asia/Pacific companies acknowledge physical climate risks. These high percentages may reflect the fact that all of these companies have operations, supply chains, and customers that span the globe, and few regions have escaped damaging extreme weather events in recent years.[34]

Yet while the vast majority of S&P Global 100 companies acknowledge risks from extreme weather and climate change, they also describe challenges in adequately understanding the risks and their implications. Several companies note that risks are either relatively minimal, too distant in time to be of concern, too difficult to quantify, or too uncertain to support business decisions for building resilience **(Box 3)**. A few companies report having reviewed potential risks from physical climate change but determining that they were unlikely to have a material or lasting effect on the company's ability to conduct business. Wal-Mart, for example, explains that "[t]he extent and nature of potential [climate] impacts are uncertain but could range from increased energy or cost requirements in operations to increased costs for our suppliers and customers. At this time, we have not identified any actionable financial implications that rise to a level that would enable commercial action."[35] These challenges are echoed in the case study interviews and workshop discussions, and provide insight into some of the obstacles that exist within companies for building corporate resilience (Section III describes these barriers further).

> ***"The high uncertainty concerning physical risks [of climate change] challenges the business case for analysing physical risks, and makes investment in adaptation plans potentially risky."***
>
> *—Credit Suisse*

FIGURE 5: Sectors Acknowledging Climate Risks



Source: C2ES Research (2012).

Box 3: Uncertainty Is a Barrier to Action

Uncertainty about climate changes presents difficulties when decisions need to be made today that have long-term impacts on the business. Nearly one-quarter (24) of S&P Global 100 companies report as a challenge the uncertainty associated with the nature, timing, location, or severity of climate change impacts for deciding how and when to invest in resilience beyond what they consider business as usual. Anglo-American explains that while "[i]t is not practical to quantify the financial implications pertaining to uncertainty[,] ... it is clear that without certainty, we are unable to plan optimally for climate changes in the future."[36]

Companies are often uncomfortable applying projections about future climate changes to business operations. Not enough detailed data are yet available for companies to adequately understand or anticipate climate impacts at the facility level, where decisions are often made. This lack of information affects how companies perceive and prioritize risks. Even when detailed studies are available, uncertainty ranges are often too broad to be useful in determining the business implications. And climate change impacts are location- and situation-specific, such that response strategies have to be considered within the context of other business factors, which themselves harbor inherent uncertainties. Global insurer Credit Suisse summarized the challenge succinctly: "The high uncertainty concerning physical risks [of climate change] challenges the business case for analysing physical risks, and makes investment in adaptation plans potentially risky."[37] Moreover, climate change impacts are often projected over several decades in the future, making it even more difficult to build a business case for preparing the company now.

Even when risks have been specifically identified, these challenges can still be too big to overcome. For example, in HSBC's survey response for the 2012 Carbon Disclosure Project, the company reports that it investigated three potential risks to its global business—extreme heat and water shortages in India, a super typhoon in Hong Kong, and a Category 4 hurricane hitting Manhattan—and still concluded that the "[u]ncertainty surrounding physical risk makes it difficult to determine the likelihood and impact, and hence planning mitigation and adaptation strategies." Current resilience activities, therefore, continue to focus on steps that are already operational imperatives and meet business continuity needs under current climate and extreme weather conditions, steps such as diversifying supply chains, exploring alternative technologies, or investigating more resilient energy sources.

Section III provides additional detail on barriers to taking further action.

MAJORITY OF COMPANIES HAVE EXPERIENCED IMPACTS OR EXPECT TO WITHIN FIVE YEARS

The timing of potential climate impacts is a critical element of companies' decision-making about when and how to enhance their resilience, for example, by investing in upgrading equipment or modifying preparedness plans. Over half (55) of S&P Global 100 companies reported they have already experienced the effects of extreme weather and climate change (38 companies) or expect to within the next five years (17 companies) (**Figure 6**). For most companies, business planning activities focus on timeframes of just a few years—the length of time of greatest financial interest to the company and over which uncertainties are relatively manageable. The more companies perceive near-term risks, the more motivated they are to upgrade their planning and response strategies; the likelihood of near-term impacts give them solid reasons to depart from historical assumptions and adopt a perspective that reflects the current reality of intensifying climate change.

Of the companies providing a timeframe for experiencing impacts, all of the Asia/Pacific headquartered companies and a majority of European companies have already experienced impacts or expect to in the next five years. U.S.-based companies were most likely to say that the timing of climate impacts is still unknown, perhaps reflecting their sensitivity to the ongoing public debate in the U.S. concerning the causes and effects of climate change.

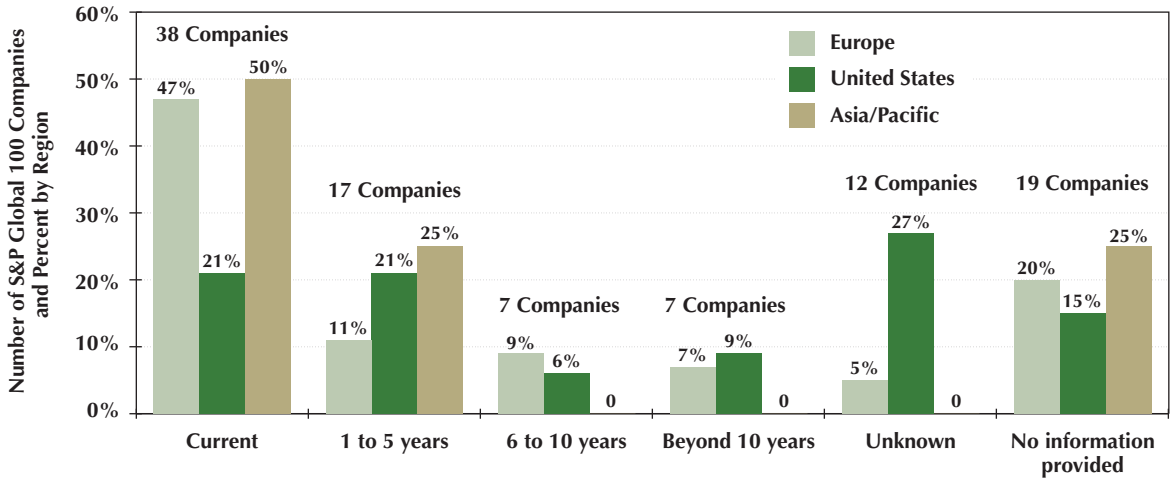
COMPANIES ARE MOST CONCERNED ABOUT DIRECT IMPACTS ON PRODUCTION CAPACITY AND OPERATIONS

The three most commonly reported direct impacts of concern from extreme weather and climate change **(Figure 7)** are impacts on production capacity (57), related operational costs (47), and a complete inability to conduct their business (15). Indirect impacts—such as those on capital costs and availability, or on communities and customers—are identified far less frequently as explicit concerns.

Honda, for example, estimates production losses from heavy flooding at its automobile assembly plants in Thailand at more than $250 million in 2011.[38] Microsoft is more focused on the increase in the cost of energy to cool its data centers and development labs as global temperatures rise: "Based on US Environmental Protection Agency (EPA) statistics and rough averages across many facilities, an increase of 1°F would represent a potential increase of 4–5% in energy costs to run air conditioning."[39] Royal Philips Electronics notes that sea level rise could result in increased capital costs, possibly "in the millions of Euros," if the need arose to rebuild data centers, network sites, or offices in less vulnerable locations.[40]

Yet without facility-level information about climate change impacts, many companies struggle to quantify the potential financial implications of extreme weather events before they occur. Toshiba, which has several

FIGURE 6: Earliest Estimates for When Impacts Will Occur



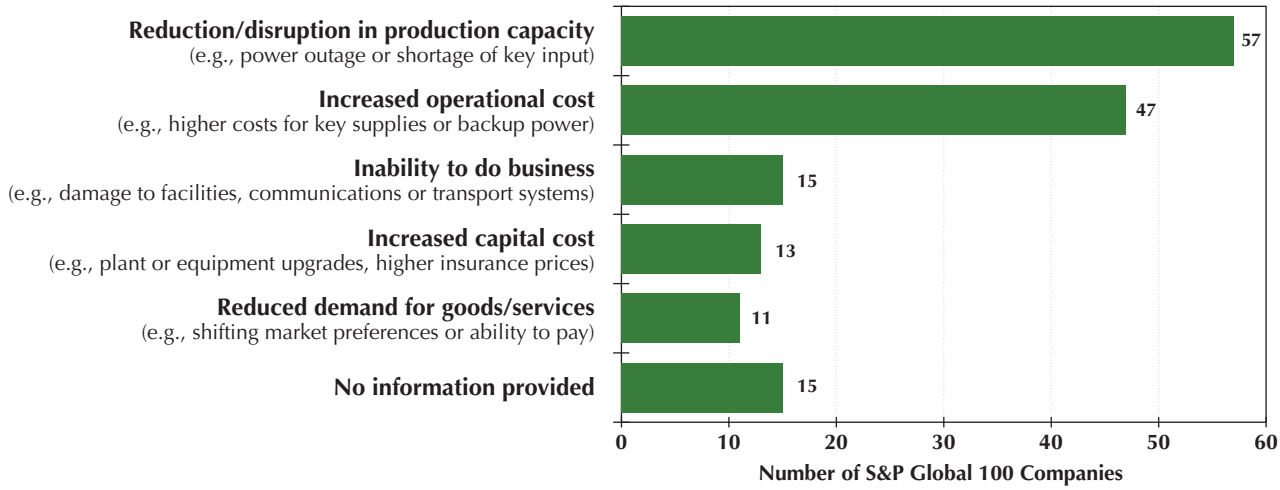
Source: C2ES research based on Carbon Disclosure Project and other information sources (2012).

production sites in Southeast Asia, estimates that if 5 percent of its facilities were shut down for a week due to increased cyclone activity or sea level rise, its sales could decrease by approximately $60 million. But "because there is no climate model that can accurately forecast abnormal weather…, it is impossible to accurately forecast the financial implications" of such risks.[41]

The banking & financial services sector is the least concerned with impacts on "production" but does express concern about disruptions to the operation of branches, facilities, and data centers **(Figure 8)**. Banks and insurance companies also express significant concern about these impacts on their clients. Barclays, for example, recognizing that one of its borrowers had operations in regions susceptible to increasing numbers of hurricanes and typhoons that could damage facilities, disrupt supply chains, and result in cash flow risks, requested detail from the borrower about the company's contingency plans and insurance coverage against business interruptions arising from weather-related events.[42]

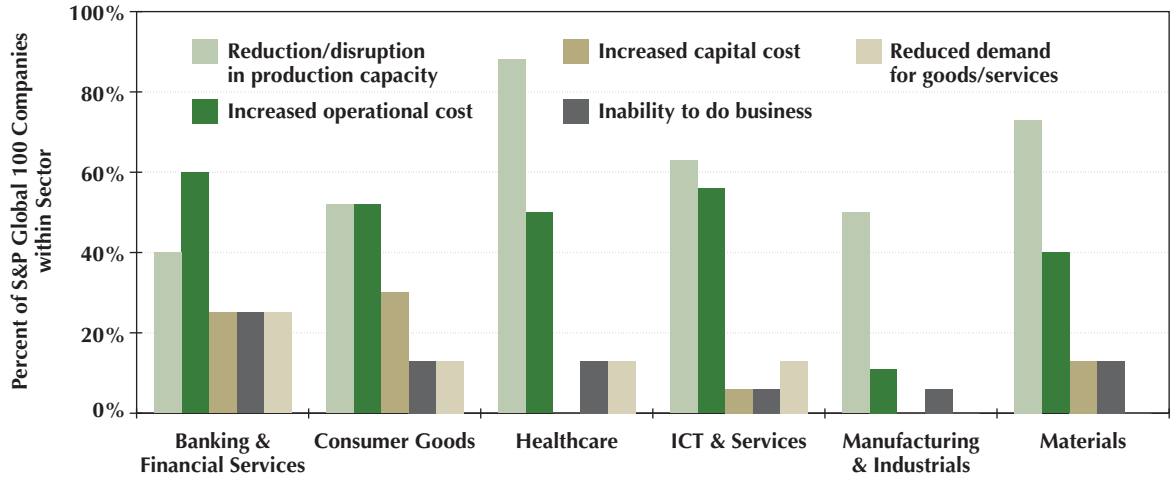
The banking & financial services sector also shares broad concerns about associated increases in operational costs, likely related to the cost of repairing damage after events and of bringing systems back on-line, and the need

FIGURE 7: Top Five Current or Expected Impacts from a Changing Climate



Source: C2ES research based on Carbon Disclosure Project and other information sources (2012).

FIGURE 8: Top Five Current or Expected Impacts from Changing Climate, by Sector



Source: C2ES research based on Carbon Disclosure Project and other information sources (2012).

for greater redundancies for operational continuity. The manufacturing & industrials and healthcare sectors are less concerned with increased operational costs and much more concerned with interruptions in production capacity. Several manufacturers noted that the global diversity of their physical locations provides sufficient flexibility to respond to disruptions with minimal cost. Finally, a number of companies describe concerns about extreme weather impacts on global supply chains or suppliers **(Box 4)**.

In the case study interviews and workshop discussions, several companies describe the importance of considering potential impacts on employees and communities that are outside of a business's direct control. Examples of such external risks include the ability of employees to get to work, disruptions to area transportation or communications networks, and the availability of fuels or electricity. Several companies impacted by severe hurricanes—including Entergy, Bayer, and National Grid—note that a key lesson learned was the need to expand the focus of their business continuity plans from avoiding losses and restoring their own operations to incorporating a longer, more strategic vision for addressing the needs for enhanced resilience of communities surrounding their operations.

RISK MANAGEMENT ACTIONS TAKE MANY FORMS

Most of the S&P Global 100 companies report that extreme weather has always been a business risk to manage, and it is considered when companies evaluate such decisions as facility sites, logistics, and backup power needs. The five most commonly reported methods used to manage physical climate change risks are using conventional business continuity or emergency preparedness plans, conducting a specific environmental vulnerability assessment, investing in upgraded equipment or infrastructure, transferring risk through insurance policies, and using climate change-specific research or forecasting models to supplement conventional risk management activities (**Figure 9**).

Companies based in Europe have undertaken all five types of these risk management steps, and are much more likely to have undertaken climate-specific research to analyze projected changes in extreme weather **(Figure 10)**. The primary way that most U.S. companies reported that they address climate risks is through business continuity and emergency preparedness plans, and only one (IBM) reported having undertaken an independent research initiative to analyze climate change-specific impacts that may affect its operations. Asia/

Box 4. Supply Chain Impacts in Focus

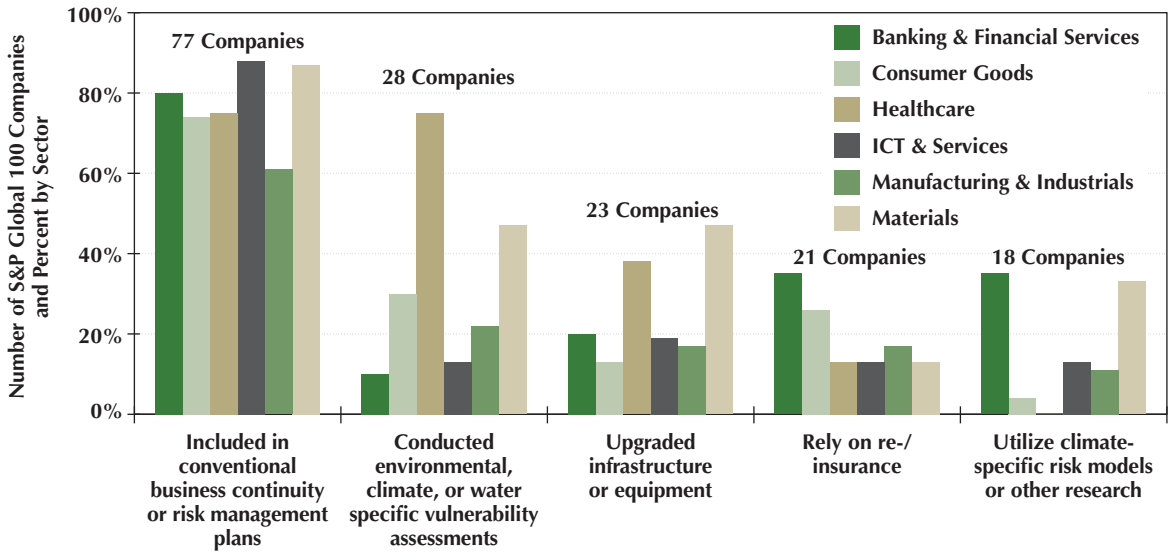
A number of extreme weather events garnered prominent media attention in 2011. Several of these, including the massive flooding in Thailand and a severe drought that stalled river barge traffic on the Mississippi River, substantially disrupted supply chains and hindered the movement of goods.

Among the 40 companies in the S&P Global 100 Index that describe physical risks to their supply chain—most of which were in the consumer goods, ICT & services, and healthcare sectors—over half (25 companies) are concerned about interruptions across their global value chain due to problems such as damage sustained by suppliers of key inputs, difficulty transporting intermediate goods, or challenges with delivering products to market.[43] Many of these companies are also concerned about long-term shifts in the availability, cost, and quality of a key input or commodity. Nestle, for example, reported that a major supply chain disruption, particularly for agricultural commodities such as coffee and vegetables, could cost the company $100 million.[44]

Nearly half of the companies (18, largely companies in the consumer goods sector) are specifically concerned about availability and quality of water supply. And risks to energy supplies are a concern for at least one company in every sector.

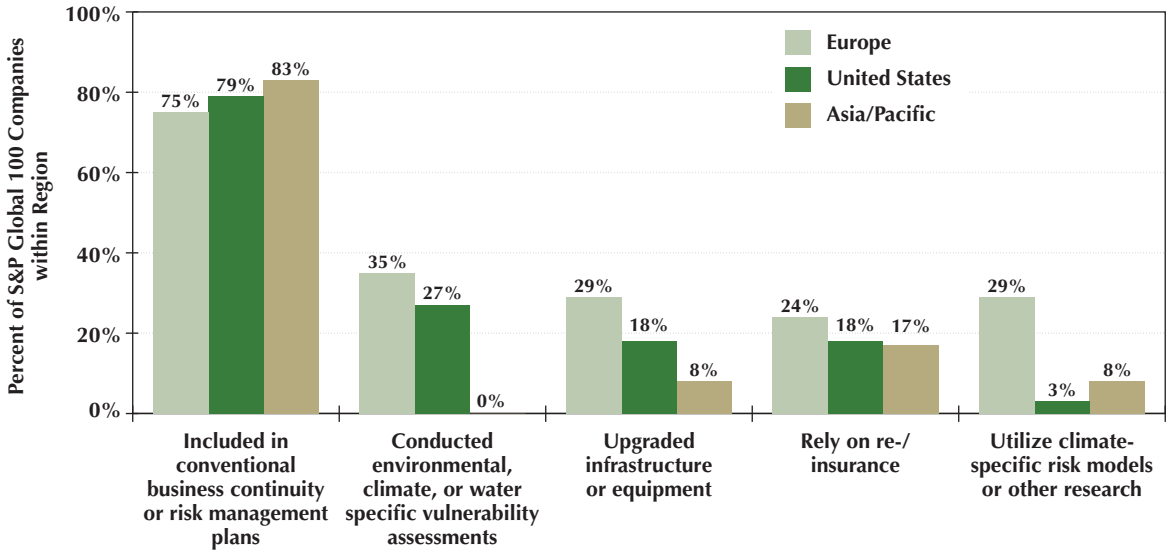
Companies are learning first-hand that even when their own risk assessments take climate change impacts into account, their operations can still be severely damaged if their suppliers have not taken the same steps. Following the floods in Thailand, Toyota suffered little or no damage to its own manufacturing facilities—a fact that it attributes to the risk assessment it undertakes when siting new facilities that includes climate change factors. Yet significant losses were sustained because its suppliers' plants were disrupted, in some cases for over a month. The shortage of parts from the flood-stricken area forced Toyota to produce 30 percent fewer vehicles than it had planned at its Japanese plants, conserve parts by cutting back on production, and postpone launching some new models.[45]

FIGURE 9: Top Five Climate Risk Management Activities, by Sector



Source: C2ES Research (2012).

FIGURE 10: Top Five Climate Risk Management Activities, by Region



Source: C2ES Research (2012).

Pacific companies also largely reported they incorporate climate-related risks into their business continuity plans.

Business continuity plans are widely used, but often do not incorporate increased risks. The majority of companies (77) report that changes in extreme weather risks due to climate change are incorporated into their existing business continuity plans and processes at a level they consider to be adequate for the challenge **(Box 5)**. This strategy of building on existing business continuity and emergency preparedness plans allows companies to leverage existing structures and expertise rather than create new mechanisms. Such plans encompass and quantify a wide variety of business risks and can be updated to incorporate new and emerging risks and practices. Minimizing business disruptions, securing supply chains, safeguarding employees, and quickly recovering from damaging weather events are already key elements of risk management, whether or not the climate is changing. Companies are prepared, for example, to shift production or supplies to an unaffected facility, maintain adequate stocks of raw materials, or arrange for alternative transportation in the event of major weather disruption. From a business perspective, the cause of an extreme weather event is not important; what matters are the planning and practices that minimize disruptions and quickly enable operations to resume.

However, the damage that companies have sustained over the past few years (Table 1, page 3) suggests that existing plans are not sufficiently robust to prepare companies for the full range and severity of climate change impacts. Business continuity and enterprise risk management plans typically draw upon a historical picture of risk. Consequently, they often do not consider the increasing intensity and frequency of certain types of extreme weather events that are resulting from climate change. Several S&P Global 100 companies report, for example, that the unanticipated severity of flooding in Thailand and the Fukushima disaster in 2011 tested their plans and highlighted where they fell short. For example,

Box 5. Examples of Using Existing Risk Management Plans to Address Climate Change Impacts

Multinational Spanish banking group **Banco Bilbao Vizcaya Argentaria** has a total of 128 business continuity plans implemented in 25 of the 32 countries in which it operates, at a cost of approximately $10 million. These are aimed at ensuring that it is prepared for any possible interruption in its activities, including from extreme weather episodes that might be due to climate change. These plans were put to the test during floods and power outages in Venezuela, La Niña-triggered floods in Colombia, and storms and tornados in Alabama. By implementing its business continuity measures, in each case BBVA was able to continue to render its critical services and comply with its obligations to society and various authorities.[47]

Bayer maintains a flexible global production system in order to ensure safety, provide for continuity of operations, and meet obligations to customers in the event of an extreme weather event. Its globally distributed manufacturing sites and supply chains ensure that Bayer is able to shift supply of products among sites in the event of a catastrophe. The company's existing risk prevention practices and emergency response plans can be readily adapted if weather extremes increase in the future.[48]

BP projects implementing environmental and social practices, part of its operating management system (OMS), are required to assess potential impacts from climate change and to manage any significant risks through the existing risk management process and using local context and project-specific risk assessments. For projects where climate change impacts are identified as a risk, BP's engineers typically address them like any other physical and ecological hazard rather than as a discrete category, and they periodically review and adjust design criteria and engineering technology practices accordingly. For example, drainage designs are adapted based on anticipated frequency and severity of storms.[49]

In **ABB**'s operations, potential climate change risk is addressed in the company's comprehensive enterprise risk management process. Issues considered include increased storm activity, heavy precipitation, floods, rising sea levels, availability and quality of water supplies, and risk of disease outbreaks. A wide array of risks is mapped out at country, regional, and divisional levels, and a consolidated risk map is generated. Reviews of facilities are conducted annually or biennially, and all facilities are required to develop, implement, and test business continuity plans.[50]

the risk assumptions in Panasonic's map of manufacturing areas in Thailand accounted for flooding of one to three meters, and the floods surged to four. Three of Panasonic's factories were inundated, underscoring the need to reassess global hazard information and risk assumptions worldwide.[46]

Vulnerability assessments. Of the S&P Global 100 companies, 28 have conducted environment- or climate-related vulnerability assessments of all operations or of key sites or suppliers. Companies employ a range of analytical methods, which vary considerably in their ability to incorporate an increase in risks of future extreme weather and climate change. A few companies (18) have undertaken or commissioned independent research to analyze impacts over the long term, sometimes using climate-specific risk models or tools. Financial services and insurance companies most often conduct this type of detailed assessment in-house. Several other companies had also undertaken extensive modeling-based assessments, typically focusing on those facilities identified as most at risk through a screening process, and typically in partnership with a government entity or university. Companies that are investing in long-lived assets (mines, ports, energy systems) are most likely to have undertaken location-specific, detailed modeling assessments with multiple scenario sensitivities, methods that provide the most in-depth information but are costly to do.

Investing in infrastructure or equipment. Twenty-three companies have taken steps to upgrade equipment or infrastructure to protect against climate change impacts (such as building flood walls or moving data centers to higher ground). Companies in the materials sector (particularly oil & gas) are more likely to have invested in such steps. For example, after the devastation caused by Hurricane Katrina, in 2006 Shell installed re-designed clamp systems for securing rig structure to all its platforms in the Gulf of Mexico, making the clamp systems four times stronger. Anglo-American, after disruptions to mining operations from excessive rainfall in 2010 and 2011 in Australia, upgraded pumps, pipelines, roads, flood protection infrastructure, and mine drainage systems.[51]

Transferring risk through insurance. Only 21 companies reported using insurance or re-insurance as a part of their risk management strategy. For example, Merck works with its insurers to perform an evaluation of potential risks and to take corrective actions for all facilities that are in low-lying areas or otherwise face severe weather risks.[52]

Other risk mitigation activities. Activities that companies mentioned, though less frequently, include:

- Ensuring *adequate stock of key inputs or raw materials,* including back-up or self-generated electric power
- *Diversifying sources of key inputs* threatened by physical climate change impacts
- Adopting a resilience-related *corporate target or goal,* e.g., for water or energy conservation that would help mitigate the impact of supply interruption
- *Engaging with suppliers of key inputs* to improve event response planning or capacity building
- Working with *business-to-business partners or through industry groups* to identify best practices
- *Engaging with government agencies* as a key component of climate resilience strategies
- Telecom companies indicate that they consider weather or climate factors in *product design*

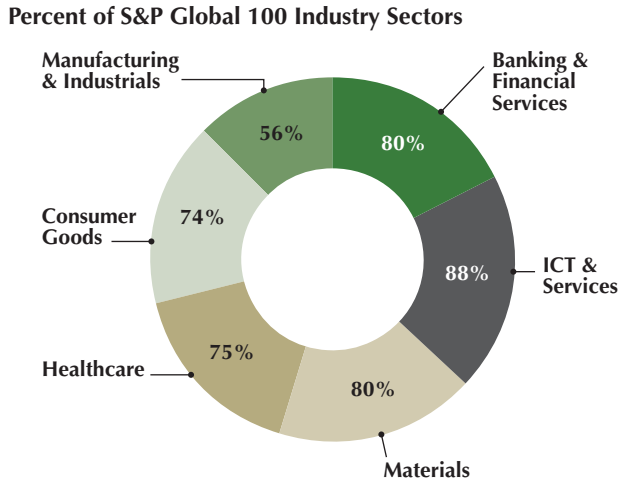
Steps companies have taken to manage and mitigate risks are described in detail in Section IV.

COMPANIES SEE CLIMATE-RELATED BUSINESS OPPORTUNITIES

The majority of S&P Global 100 Index companies (75) anticipate that the physical impacts of a changing climate will bring potential new business opportunities. These companies are broadly dispersed among industry sectors **(Figure 11)**. Many of these companies described that making their operations or supply chain more resilient to extreme weather and climate change would generate a competitive advantage over other, less-prepared companies.

The five most commonly reported types of current or emerging business opportunities **(Figure 12)** include increased demand for existing products or services, increased demand for new products or services, reduced operational costs, increased production capacity, and expanded investment opportunities. Opportunities for providing products and services was identified most readily (37 and 27 companies, respectively), indicating that companies believe they already provide solutions, or would develop new solutions, that can address the challenges that customers will face under climate change **(Table 3)**. Healthcare companies in particular (63 percent of the sector) described potential new market growth for existing solutions. Bayer's mosquito nets with pesticide defenses could find wider application if warmer conditions result in new areas at risk from malaria. Bayer

FIGURE 11: Sectors Identifying Opportunities



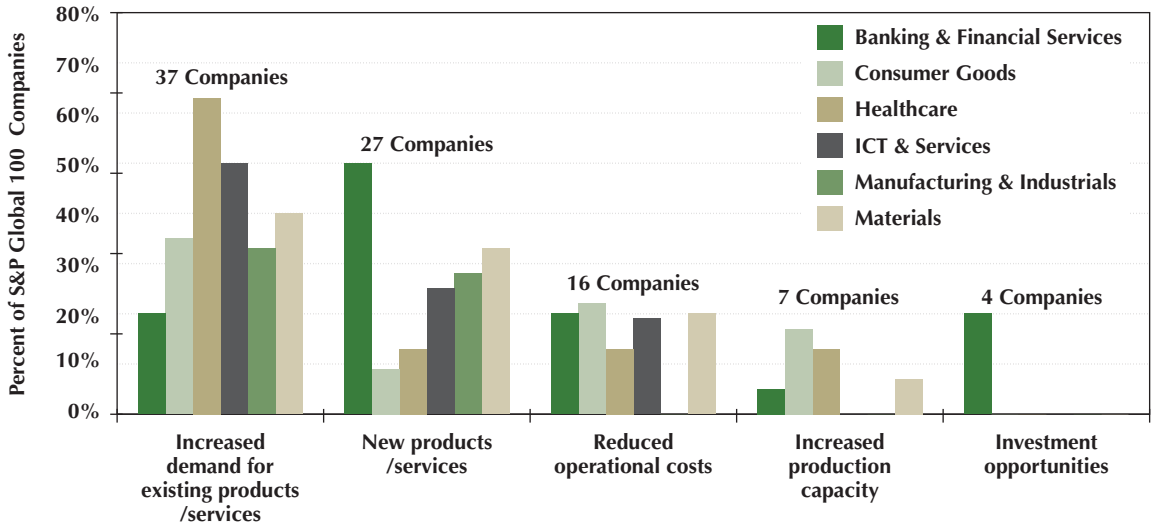
Source: C2ES Research (2012).

is also developing drought- and salinity-resistant crops that could reach wider markets in a changing climate. Some companies in the manufacturing & industrials sector, though less likely overall to identify business opportunities from changing climate, do describe opportunities for product and service growth and innovation. Given rising global concerns about water availability for residential and industrial applications, many of these companies, including GE and Dow, are developing improved water-efficiency technologies that could capture larger markets in more drought-prone areas. Honda expects increased demand for its solar-powered generators that can readily be delivered to emergency sites. Banking & financial services companies (50 percent of the sector) see the greatest potential for developing new products and services.

A number of companies (16) linked their efforts to build greater resilience to opportunities for reducing operational costs. Targeting energy or water conservation, for example, would both mitigate the impact of an interruption in supply and reduce costs. Or weather-related risk mitigation efforts at facilities might be rewarded by insurers through reduced premiums. Yet, surprisingly given the operational nature of these opportunities, no manufacturing & industrials companies reported this as an opportunity.

A few companies (7) reported opportunities to increase production capacity. In particular, consumer goods companies (17 percent of the sector) expected warmer temperatures to boost agricultural yields (although companies do not mention whether increased yields would outweigh damages to crops from extreme weather events or other indirect, climate-related impacts from pests or pathogens). For oil & gas companies,

FIGURE 12: Top Five Current or Expected Opportunities from a Changing Climate



Source: C2ES research based on Carbon Disclosure Project and other information sources (2012).

changing climate is also substantially changing conditions in the Arctic, for example, opening up the potential for new areas for exploration and shorter transport routes across the region. There has already been a 34 percent increase in shipping vessels in the Arctic since 2008.[53] With Arctic oil reserves estimated to be worth $9 trillion,[54] Chevron is exploring the implications of these changes through its Arctic Center, and Shell has been awarded the first permits for exploration in the region.

Banking & financial services was the only sector that listed "investment opportunities" as a significant area for business growth, reflecting interest in new financial or risk transfer instruments such as weather futures and catastrophe bonds.

Very few companies provided information on *how* business opportunities were identified or pursued. The few companies described how ideas were identified, including through studies or scenario analyses intended to identify climate risks to the business; by tracking global "megatrends" (e.g., increased water scarcity, food shortages, or migration patterns); through discussions with key customers and suppliers; participation in industry or public-private sector working groups; or relying on in-house capabilities and resources (particularly in the

TABLE 3: Business Opportunities from Extreme Weather and Changing Climate

SECTOR	BUSINESS OPPORTUNITIES
Healthcare	**GlaxoSmithKline:** products to prevent water-related illnesses **Johnson & Johnson:** treatments and vaccines for climate-related diseases **Bayer:** insecticide treated mosquito nets for controlling malaria
Banking & Financial Services	**Credit Suisse:** lending for developing infrastructure resilience **Goldman Sachs:** catastrophe-linked securities to transfer risks of extreme weather events **Standard Chartered** and **Swiss Re:** financing for farmers affected by weather risks **HSBC** and **Munich Re**: weather-related insurance for crops and forests
Chemicals	**BASF:** water purification systems to prevent disease **Dow:** membranes for more energy efficient water desalination and filters for purifying and reusing water **DuPont, Bayer,** and **BASF:** drought-resistant seeds
Consumer Goods	**Coca Cola** and **PepsiCo.:** practices and processes to reduce water consumption **Nestle:** higher yields for raw materials such as coffee, cocoa, maize **Nokia:** mobile technology to manage water footprint **Samsung:** air conditioning units for warmer climates
Building Materials	**BASF:** insulating foams for temperature regulation **3M:** chemical to bond roof tiles in hurricane areas **Holcim:** concrete building materials that are stronger, store passive heat (and coolness), and are more resistant to storm water **Saint-Gobain:** systems to protect dikes from wave impacts; materials to reinforce and rebuild structures after a damaging event
Manufacturing	**Honda:** emergency solar powered generation units for homes and electric vehicles **Intel:** developing high-performance computational models to enable more accurate climate and weather predictions
Oil & Gas	**Chevron:** increased access and production in Canadian operations **Shell:** exploration of Arctic oil reserves[55]

Sourced primarily from responses to Carbon Disclosure Project's 2012 Investor Survey (Carbon Disclosure Project 2012).

science- and R&D-based industries such as chemicals, pharmaceuticals, and oil & gas). Among the case-study companies, Weyerhaeuser generated ideas for new business service opportunities through broader conversations with clients about sustainability and climate change mitigation challenges. Specific company activities are described further in Section IV, Table 7, below.

In general, the discussion in public documents about pursuing business opportunities was much less specific than on how companies are addressing risks. It is also interesting that while the majority of companies say they see business opportunities from physical climate changes, the examples offered by about 20 of these companies were fairly vague or, in some cases, were more related to reducing greenhouse gas emissions rather than to market opportunities. This suggests that companies are as yet less aware of the challenges associated with the physical effects of climate change than they are about efforts to mitigate climate change and reduce greenhouse gas emissions.

III. MAJOR BARRIERS TO BUILDING BUSINESS RESILIENCE

Most companies examined in this study report that they have taken some steps to protect themselves against disruptions from extreme weather and climate change impacts. But only a few have developed plans that fully reflect the profile of increasing risks. Current business activities to build resilience are largely a continuation of existing practices and policies, and focus on steps that are designed to address current climate and weather conditions. Few companies are taking action beyond no-cost or low-cost measures (if taking any action at all) and are adopting a "wait-and-see" approach given their uncertainty about how precisely climate change will impact the business.

Given the complexity of predicting climate risks, this cautious response is not surprising. Yet as recognition grows that the near-term risks of extreme weather and climate change impacts are increasing, more companies will likely incorporate these changing risk factors more explicitly into their operational and capital planning decisions. This study identified a number of critical barriers to their doing so.

The inherently uncertain nature and long time horizon of the changes involved. Even though the vast majority of climate scientists predict significant global changes across the coming decades—more intense storms, more frequent droughts, sea level rise—uncertainties associated with the magnitude, timing, and location of such impacts remain. Where information about impacts is available, the uncertainty ranges of the occurrence of a given event are often too broad for a business to use for concrete planning processes. And the nature and magnitude of risks change at each site in each country every year, making it difficult for companies to develop a long-term picture of a wider range of possible risks and responses that will be applicable to each business type and location. Moreover, addressing climate change impacts, which are projected to play out over the next 10, 50, and 100 years, requires a longer-term approach than many companies are used to. Yet while uncertainties do exist, businesses must recognize that uncertainty cannot be an excuse for inaction. As Jeff Williams, Director of Climate Consulting at Entergy, explained: "Scientific uncertainty is a reason for action, not delay."[56]

The absence of easily accessible, scientifically credible, and user-friendly information on changes in weather-related risks. Companies find it difficult to locate climate change information and apply it to operations or to specific performance metrics (e.g., how will floods affect production capacity? to what extent might heat waves affect energy supply and costs?). Many companies are unsure where to look for information on past and future projected climate. They also have a difficult time sorting out the sometimes-conflicting information. Moreover, there is a disconnect between scientific and business language: the large geographic areas and long time horizons that many climate studies provide are difficult to translate into short-term and location-specific business decisions. In some cases, even current metrics are outdated: hurricane categories, which consider wind velocity but not coastal surge intensity, inadequately cover risks and "lull people into a false sense of security," as one company representative put it. And there are often barriers to integrating information into decision-making processes (e.g., how should climate risks be incorporated into capital investment planning? how do extreme weather and climate risks affect strategic priorities that are made on annual, multi-year, or multi-decade timescales?).[57]

> ***"Scientific uncertainty is a reason for action, not delay."***
>
> *—Jeff Williams, Director of Climate Consulting, Entergy*

Companies would like to have a centralized place to turn to for information about the changing profile of climate risks in the United States, similar to the UK's Climate Impacts Programme, a "one-stop-shop" for tools and resources. Serving that role and making this information more user-friendly are important goals of the U.S. National Climate Assessment, and similar efforts have been undertaken by research organizations in other countries (see Table 5, page 31, for a list of resilience planning resources and tools).

The limitations of current climate change modeling tools. Climate change modeling tools estimate the probability of extreme weather and catastrophic events, and help analyze the uncertainties associated with the nature and timing of climate variability and extreme weather. Many companies begin their risk assessments with the Intergovernmental Panel on Climate Change (IPCC)'s global climate change projections, but soon find that the geographic scale is too coarse to support decision-making locally. Not enough detailed data are yet available for companies to adequately understand climate change impacts at the facility or operational level, where decisions to fortify systems or add redundancies are often made. Companies need a way to connect the information available from climate models to the companies' specific issues of concern. They need tools that refine climate change information to address specific variables (e.g., duration of extreme heat, run-off from higher-than-average rainfall) at specific locations, and that can cover shorter timeframes of concern to companies. The UK's Climate Impacts Programme provides some of the most detailed data publicly available in the world, but it is limited to a single country.

Low levels of awareness and expertise within a company. While most companies have risk management specialists, few have expertise related to extreme weather or climate change that would allow these factors to be incorporated into business decision-making. Likewise, very few companies have the resources to closely follow climate-related scientific developments. Several case-study companies describe challenges with building awareness internally and obtaining senior management buy-in for investing in steps that would build greater resilience to climate change impacts.

A context of multiple stresses. Companies are recognizing that climate change impacts are location- and situation-specific and response strategies have to be considered within the context of other related stressors. Just as it is not possible to link climate change, writ large, to any specific extreme weather–related event, it is also often difficult to disentangle the impacts of increasing climate risks from stresses caused by increasing populations, migration, urbanization, or coastal development. These factors and their cumulative effects amplify the impacts of climate change: for example, population growth in the U.S. West and Southwest combined with the trends toward less rainfall or more severe droughts puts unsustainable pressure on the region's limited water supply. Climate change can complicate existing stresses, and companies' failure to adequately consider the cumulative impacts on the systems as a whole could substantially undermine the effectiveness of their vulnerability assessments and response strategies.

Competition for company resources. Companies' investment in building resilience competes with other business objectives and resources, many of which are more immediate and tangible. Short-term costs and cash flows are often considered more important than benefits that may not be realized until much later. Capital, especially for smaller companies, is limited, and investments in long-lived assets such as facilities or equipment, or even in product development, involves high upfront costs and financial hurdles. Given the uncertainty of the nature and timing of extreme weather events and the lack of detailed, location-specific data on climate change impacts, companies find it difficult to justify their decisions to invest in resilience based on climate risk factors alone.

Lack of investment by governments in public infrastructure. Extreme weather will impact public infrastructure that companies rely on but which are beyond their "fence line"—roads, public transport, water provision, and communications systems. Some national governments have taken steps to build their resilience to climate change by upgrading public infrastructure. But the willingness—and capacity—to do so varies from state to state and country to country. In many places, including the United States, in the absence of government efforts to upgrade its own infrastructure or even guidance on what is needed for preparedness, many businesses are adopting a more cautious "wait-and-see" approach. Without clear government signals, some companies believe that it is simply too early to take action, or they consider that "building resilience" and committing to preparedness is as much the government's responsibility as it is theirs.[58]

IV. A FRAMEWORK FOR MANAGING CLIMATE CHANGE RISKS: EMERGING BEST PRACTICES

Enterprise risk management frameworks help companies identify, categorize, and quantify risks—and opportunities—in order to assess their likelihood and the magnitude of their impact on the business, determine a response strategy, and monitor progress. This research confirms that existing risk management frameworks are an often-used process or tool for managing the impacts of extreme weather.[59] Companies are integrating climate change considerations into existing risk management practices—considering physical risks as a core, company-wide business risk rather than as a separate "sustainability" initiative.

To maximize the effective use of this framework for managing climate risks, companies should consider the following:

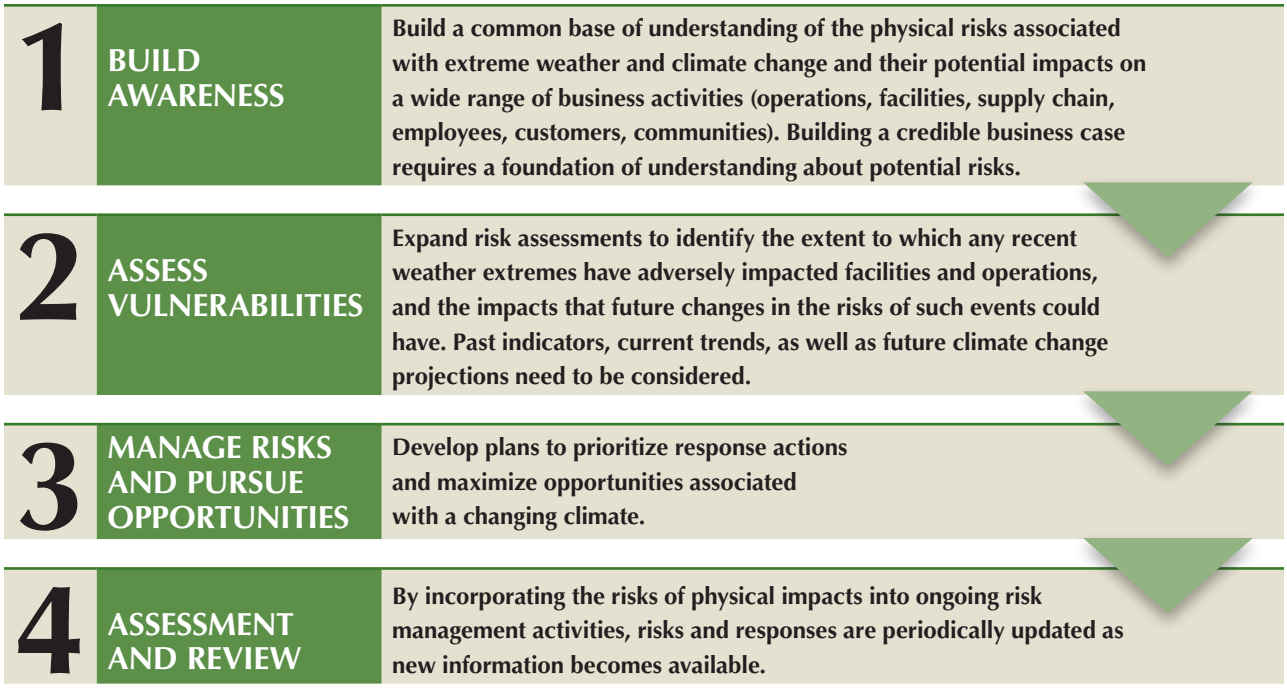
- Historical records and trends concerning the likelihood and magnitude of climate risks are not sufficient to guide present-day guide decisions. Indeed, historical trends can seriously mislead companies attempting to plan intelligently for the future. Past and current trends must be considered together with projections of future climate change impacts.
- Uncertainty around predicting future climate change impacts requires an iterative risk management process in which short-term decisions are placed into a longer-term context. Near-term investment in floodwalls, for example, may be cost-effective only to a certain level of long-term sea level rise or flood risk. Decisions that lock-in strategic commitments or foreclose a set of future options should generally be avoided in favor of decisions that promote flexibility and allow managers to course correct as new information becomes available.[60]
- Information tailored by asset type or regional location is needed and may be different for each business unit or operation. The challenge is to develop a sufficiently detailed assessment of risks across a broad spectrum of assets and geographies that will allow for business units to implement effective local strategies. Companies can begin by focusing analytical efforts on those operations and facilities identified most at risk by vulnerability assessments.
- Benchmarking against competitors or sector peers—an important performance assessment tool—can be difficult when impacts and opportunities are very location- and situation-specific. Therefore, understanding what sufficient resilience means for the company means sharing lessons and learning from peers and partners.

Figure 13 provides a framework for applying business risk management approaches to climate change impacts. Since climate change factors are difficult to estimate and quantify in detail, few companies currently include "climate change"-specific data in their company-wide enterprise risk assessments (although in some cases related risks such as energy reliability or water availability are being used as proxies). Most companies instead are using sensitivity analyses or qualitative guides to help business managers with decision-making on a local level. These and other risk assessment and management practices are described below.

STEP 1: BUILD AWARENESS

For a growing number of companies, recent disruptions caused by extreme weather have driven home that increased risks exist today and can be costly. But with the passage of time, today's extreme weather event is often quickly forgotten as other business priorities take over. A deeper understanding of the future risks of such events must be developed across the company as a foundation for long-term, realistic business planning and decision-making.

FIGURE 13: Four Steps for Managing Climate Risks



Outreach and communications. Education efforts should be targeted to employees with a very wide variety of responsibilities. Actions to assess and manage impacts will involve employees at all levels of the company, from senior officials at headquarters to employees at facilities and suppliers worldwide. While staff involved in relevant decision-making will vary by company, they could include:

- Corporate risk managers
- Corporate insurance planners
- Strategic planners
- Financial risk managers
- Supply chain managers
- Business continuity and emergency response managers
- Facility managers and planners
- Sustainability officers
- New product developers

Education and communications efforts will often need to address employees' commonly held beliefs that future conditions will be similar to those experienced in the past. Communications with staff often focus on increases in the risks associated with certain types of extreme events, while avoiding debates about causality of individual events. Companies such as Rio Tinto are approaching this challenge by framing "climate risk" as business planning actions that they can take in the short term that will build the adaptive capacity needed to better manage risks and strengthen competitiveness over the long term (**Box 6**).

A number of public utility companies also recognize the importance of strengthening public outreach and communications systems to customers and regulators as an increasingly critical element of their emergency response plans. They underscore the importance of keeping customers and regulators informed of their efforts to restore service during and after an extreme weather event, a factor that tends to be a critical element in how company performance is evaluated during the event and how costs are recuperated afterwards.

> ***"'Climate risk' is a facet of business risk. Building resilience to a changing climate is about doing what companies have always done—strategic planning, risk assessment, investing in infrastructure, safeguarding employees—using the best information possible to make informed decisions."***
>
> *—Jeff Hopkins, Policy Adviser, Economics & Environment, Rio Tinto*

Research and education. While many studies on climate change are lengthy technical assessments not well suited for widespread distribution within companies, good examples of more accessible materials do exist. National, state, and local agencies and universities are increasingly issuing reports and making climate change experts available to communicate with companies and their stakeholders. Several companies reported they have incorporated data and information into their analysis from climate or weather sources such as the Intergovernmental Panel on Climate Change (IPCC), the U.S. National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey, and the UK's Met Office. (See Table 5, page 31, for a list of resources.) All of the case-study companies have worked directly with scientists and researchers from government agencies or universities. Such studies form the basis for a variety of outreach and education efforts, including:

- Briefings for senior managers
- Webinars for employees directly involved in planning for and managing climate-related risks
- Informational materials and guidance for specific business units, projects, or investments
- Periodic updates as new information becomes available

Leading companies are starting now to collect information and build platforms for education. This is particularly important when companies are faced with investment planning for assets that can last for up to 50 years or are developing new innovations that can take decades to come to market. These companies are building adaptive capacity—developing skills, collecting

Box 6. Building Adaptive Capacity at Rio Tinto

Since 2002, Rio Tinto's corporate Energy, Environment and Climate Change (EECC) group has been evaluating risks to its operations from climate change. These efforts began with a "desk-top" study of potential regional impacts involving regional business managers, based on the key scientific findings in the IPCC's 2001 Third Assessment Report. This was followed in 2005 by a study involving experts from the UK's Hadley Centre, which also served as a basis for a briefing on recent developments in climate science for senior company executives. A few years later, a more detailed assessment was developed by experts at the University of Oklahoma of company sites determined to be at greatest risk.

Based on the knowledge gained through these efforts, the EECC group developed guidance for business units to describe how they can apply the company's enterprise risk analysis process to energy and climate change risks. The guidance serves as a tool to help operations managers better understand the kinds of physical climate change issues that the business units need to consider, and serves as a platform to build expertise, capacity, and resilience strategies over time.

Long-term planning and lessons from past weather events are already built into business continuity and site planning procedures, and these are being supplemented with climate change projections over longer time horizons. For example, operating sites are beginning to consider the physical risk of climate change by including:

- Climate projections in water management programs, such as the long-term assessment of sustainable water supplies and future flood risks
- Climate change in the engineering design of new projects, so that they are sufficiently robust for extreme events likely to occur
- Climate change variables in disaster management planning
- Climate change impacts in ice road design and contingency planning

information, and evaluating management options—that will position them to learn and adapt in the longer term. As one Bayer executive put it, "Being forward-thinking affords market advantages. Providing information to our scientists and strategic planners now about climate changes occurring over the 10, 20 or even 50 years is helping to inform decisions today about innovation and competitiveness for the future."[61]

STEP 2: ASSESS VULNERABILITIES

Perhaps the biggest hurdle for companies to overcome in building resilience is the need to undertake a systematic assessment of their vulnerabilities to extreme weather and climate change.

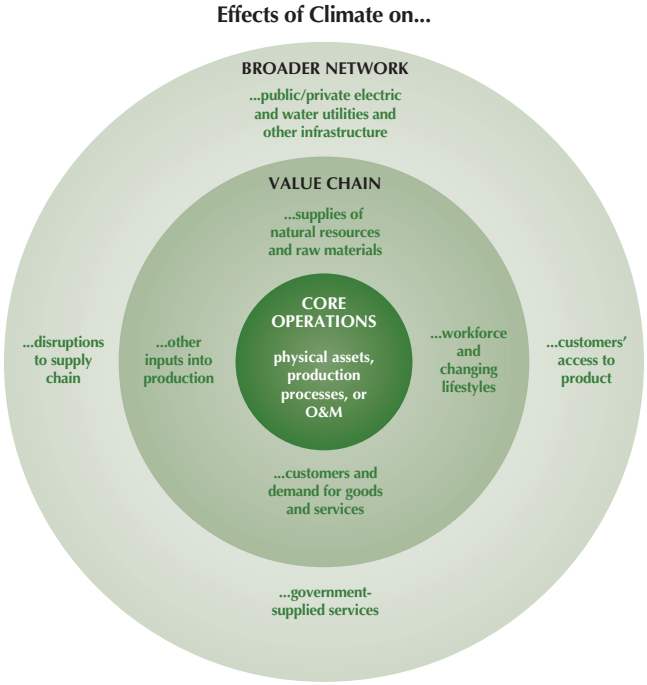
Scope. In considering potential vulnerabilities, companies examine their core operations (their own facilities and assets) but also a broader range of potential impacts that, while not directly within their control, could affect their bottom line. Several companies describe the importance of considering potential impacts on employees and communities when building resilience to climate change. Several companies that had been affected by severe hurricanes—Entergy and Bayer in the U.S. Gulf Coast, National Grid and American Water in the Northeast—note that a key lesson learned in the aftermath was the need to expand the focus of their preparedness plans from avoiding losses and restoring operations, to incorporating a longer, more strategic vision for rebuilding and addressing the resilience of neighboring communities. A Risk Disk **(Figure 14)** illustrates the scope of potential impacts on core operations, value chain, and broader network that should be considered as part of any comprehensive vulnerability assessment. Examples of external risks include: the inability of employees to get to work, disruptions to area transportation or communications networks, and the unavailability of fuels or electricity. Companies also consider relevant non-climate factors that affect vulnerability, such as changes in land use, increases in population, shifts in migration, increases in urbanization, and competition for scarce resources. While business continuity and emergency preparedness plans can seek to mitigate some of these external impacts, wholesale efforts to avoid these problems or mitigate their risks generally fall outside a company's direct control.

Methods. Today there is no one standard approach for conducting a business vulnerability assessment, as companies use a wide range of approaches differing both in scope and methodology. They use a multitude of data and tools, including past climate data, experience with recent impact events, and the projections of climate models. This diversity of approaches indicates that efforts are in their early stages of development.

Central to companies' abilities to effectively manage their risks is the ability to predict future trends. Some companies rely primarily on data on past weather variability; however, these data must be adjusted to reflect the fact that climate is changing and historical records likely will not accurately reflect future conditions. Other companies attempt to incorporate the forward-looking projections of climate models. Since no one definitive projection of changing climate exists (or would be scientifically supportable), these companies have an array of models to choose from.

Furthermore, while climate models produce much useful information about temperature, precipitation, or sea level rise, their use in company assessments requires additional interpretation. Climate models' projections use a scale of over 100 square miles, and efforts to downscale estimates for use at specific sites introduce additional methodological complexity.

FIGURE 14: Risk Disk



Source: Pew Center on Global Climate Change (2009).[62]

Finally, some of the physical impacts of most concern to companies are not predicted by climate models themselves and require the use of additional tools to transform the output from models into usable information. For example, climate models will produce changes in precipitation, but these estimates must then be run through hydrologic models to project estimates of run-off and water availability. While no one approach will work for all companies, various methods are being used to address the limitations in climate models. These provide useful information for companies in making better informed decisions about enhancing their resilience.

The types of analyses that a company will need to perform are driven by the specific needs and decision-making process within the company. Whatever the particular approach selected, a vulnerability assessment benefits from the following considerations:

- A high-level initial screening across the company, with more in-depth vulnerability assessments of high-risk facilities and operations
- Assumptions about changes in the risk profile of extreme weather and climate change impacts that are forward-looking and scientifically based
- The incorporation of changes in related factors such as land use, population growth, or competition for scarce resources that could also amplify or alter risks

Different tools and approaches used to assess vulnerabilities are summarized below and specific company examples are provided in **Table 4**. A number of resources to assist companies in this effort are provided in **Table 5** on page 31.

Screening assessments. Companies often begin by undertaking a high-level initial screening across core operations and value chain in order to prioritize those areas most at risk and in need of more in-depth assessments. The initial screening assessments, which sometimes take the form of a desk-top survey that focuses on a limited number of key parameters such as energy, water, or other critical resources, often require minimal research and draw on publicly available climate information such as recent weather observations and IPCC projections. It is intended to quickly yield a high-level picture of the most significant risks and is often a first step that can be used to guide further, in-depth vulnerability assessments and data collection at high risk operations, such as for water availability and water use at key sites **(Box 7)**.

Box 7. Tools for Assessing Water Vulnerabilities

Water-related stresses are a major concern for many companies in the S&P Global 100 and have been the focus of many in-depth assessments. Several good risk assessment tools have been developed by industry groups and through partnerships with non-governmental organizations to specifically assess water risks. Companies in the S&P Global 100 most often used the World Business Council on Sustainable Development's (WBSCD) Global Water Tool. Other tools commonly used include the World Resources Institute's Aqueduct Tool, AQUASTAT from the United Nation's Food and Agriculture Organization, United Nations Environment Program's Vital Water Graphics, and the Global Environmental Management Initiative (GEMI) Water Sustainability Tool.

The WBSCD's Global Water Tool (GWT)[63] is an often-used analytical tool that compares a company's sites with the best available information about water, sanitation, population, and biodiversity on a country and watershed basis. It allows companies to identify how many of their sites are located in extremely water-scarce areas, which sites are at greatest risk, and how many of their suppliers will be in water-stressed regions in 2050. The GWT is made up of two components:

1. An Excel workbook for data entry on site location and water use that generates a water inventory, reporting indicators, and other risk and performance metrics.
2. An online mapping system enabling companies to plot their sites with external water datasets and download those locations in a map.

The Global Water Tool is also linked to Google Earth, which provides spatial viewing of a company's site location in relation to detailed geographic information, including surface water and population density.

Historical records of variability. Some companies use historical records of weather variability and extreme events to perform a more extensive assessment of current risk and potential future damages. These records are sometimes acquired from national weather services or built internally by corporate planners or logistics managers using data and expertise from engineers and facility managers. In some cases, a margin of safety is built into the analysis to reflect the increased risks associated with climate change. For example, a company could assume that what has been a 100-year event becomes a 20-year event, or that water availability could decrease from past levels by 25 percent.

Modeling/scenarios. Climate change scenarios or detailed computer models can present a range of future impacts of most concern to a company's facilities, operations, and supply chains. Sometimes these model-based assessments are conducted in-house, but in most cases, companies work closely with experts from universities, government agencies, or consultants (**Box 8**).

Third-party assessments. Companies sometimes engage consultants or non-governmental organizations to help develop risk profiles of all operations or key production sites. Some of these are consulting firms that have expanded their services from initially assessing political or security risks, for example, to offering assessments related to climate risks. These firms offer a range of products from country-level ratings (e.g., score cards or indices) based on climate risks to more detailed assessments of the vulnerabilities of specific facilities. Companies use these services for evaluating where to locate new facilities, whether and how to invest in expanding existing facilities, and where to source supply chains.

Assessments with insurers. A number of companies work periodically with their insurers to assess (and manage) growing extreme weather risks as part of efforts to limit insurance costs. The insurance industry has long been involved in seeking to understand and assess the risks of climate change,[65] as property and casualty insurers are on the front lines of paying for damages from extreme weather. Often they are uniquely positioned to work with property owners to reduce the risks of future damage in return from reduced premiums. In addition, reinsurers such as Munich Re and Swiss Re have devoted considerable resources and staff expertise to issues related to the impacts and economic costs associated with climate change.

Box 8: Entergy's Impact Modeling Studies

After Hurricanes Katrina and Rita caused $1.5 billion in losses and left 1.1 million customers without power, Entergy commissioned one of the most comprehensive analyses undertaken of the impacts of climate change to assets and industries on the U.S. Gulf "Energy Coast." This study included detailed modeling of future economic growth in the region; the impact of different scenarios of climate change today, in 2030, and in 2050; and the cost-effectiveness of a range of resilience actions. Even without the effects of climate change, the region could expect to face losses of $15 billion to $19 billion due to continued coastal subsidence and economic growth in the region. This estimate reached $23 billion when climate changes were factored in. The analysis also identified $49 billion in near-term and longer-term actions (many of them with acceptable returns on investment) that, if made, could avert $137 billion in losses and substantially reduce the company's exposure to risk in this region. Throughout its study, Entergy took steps to engage stakeholders from the region to ensure that the analysis reflected the views of those directly affected.[64]

TABLE 4: Examples of Business Approaches to Assessing Vulnerabilities

APPROACH	COMPANY EXAMPLES
Screening Assessments	**Rio Tinto** first conducted a global "desk-top" survey of risks to all its facilities based on IPCC data and later followed up with more detailed assessments of the sites most at risk.[66] **Diageo** focused on climate-related risks that impact its six most critical agricultural commodities and their exposure to current and future risk factors.[67] **Kimberly-Clark** established an internal team to identify risks and potential steps toward resilience that are needed in response to climate change. The team looks at the potential consequences of climate change, such as which geographies and businesses may be exposed to the physical impacts of climate change and the magnitude of potential loss, as well as secondary effects such as raw material shortages and employee impact.[68] After major floods in 2010, **National Grid** conducted a flood risk assessment of over 130 electricity substations using river and tidal flood risk data from the UK Environmental Agency. From an initial set of 47 sites identified as at risk from a 100-year flood, 13 were prioritized, based on more detailed site surveys and cost projections, as warranting protection. The company plans to rebuild or elevate parts of these substations by 2022.[69] **Anglo American's** climate change strategy requires that all operations and projects undertake climate change vulnerability assessments, following which all high-risk sites will undergo detailed climate change impact assessments. This builds on its initial three-year climate change impact assessment study for selected operations that was carried out by Imperial College, London.[70] **HP** has conducted a targeted risk assessment of climate change, energy, and water. Critical HP operations and suppliers were evaluated for regulatory, physical, and other conditions related to climate change. Scenario analysis was carried out for business risks, and risk management plans were developed as appropriate. Physical risks are evaluated and considered as a part of business continuity planning and are incorporated into resilience plans.[71] **BASF's** climate monitoring expert group is observing local climate changes, including temperature changes, changes in precipitation, and extreme weather, at its 28 most important production sites in Europe, Asia, North and South America. The results of published regional climate modeling studies are analyzed and compared with the trends identified internally. Recommendations for action are generated annually and tracking the effects of climate change on sites is a continuous process that will remain in force over the coming decades.[72]
Historical Records of Variability	**Weyerhaeuser** uses detailed records of over five decades of weather variability and its impact on forests to quantify risks by region, manage its holdings, and make decisions about future investments. The company's staff of hydrologists, plant pathologists, and other experts collects real-time environmental data at sites, and key findings are incorporated back into central planning models.[73] For its planning processes, **American Water's** in-house engineering team relies on extensive historical records of its water systems' supply withdrawals and customer water usage patterns, as well as government databases, and future predictions and safety factors.[74]

TABLE 4: Examples of Business Approaches to Assessing Vulnerabilities (continued)

APPROACH	COMPANY EXAMPLES
Modeling/Scenarios	**Anglo American** has used regional climate modeling to assess long-term strategies for increasing the resilience of operations and projects in South Africa, Brazil, and Peru.[75] **GDF Suez** is developing an expertise in climate forecasting based on partnerships with several universities with a focus on the impact of climate change on its hydro power plants and wind farms in France.[76] **Rio Tinto** commissioned the UK's Hadley Centre for Climate Change to develop a range of scenarios for how changes in key climate variables over the next 25 to 50 years might affect regions where the company operates.[77] **National Grid** has evaluated its assets and business practices against impacts described by UK Government climate change scenarios in order to evaluate the resilience of its power and gas networks in a range of future conditions.[78] **Bayer** partnered with the Potsdam Institute for Climate Impact Research to develop scenarios of changes in hydrology, air temperature, sea level, and river flows that would affect the company and its markets over the next 10, 50 and 100 years.[79] **BP** is working closely with Imperial College in the UK to develop specialized climate models that help the company to better understand and predict possible impacts resulting from the changing climate. Climate impact modeling tools are available for all projects and operations to help its business managers to make appropriate allowance for the potential effects of climate change. BP used regional climate model in 2012 to inform decisions about river crossings for its South Caucasus Pipeline and review any risks associated with landslides.[80]
Third-Party Assessments	**BP** has collaborated with ArcticNet, a research organization studying climate change impacts in the Arctic, on a two-year environmental baseline study in the Beaufort Sea in Canada, where BP is in the early stages of an oil exploration project. The data will provide a useful baseline with which BP can compare future research, helping the company to understand and chart the effects of climate change in this deepwater ocean environment.[81] **Dow** is sponsoring a two-year research collaborative with Ohio State University's Center for Resilience that is exploring supply chain resilience and reliability, helping companies to analyze their capabilities and vulnerabilities to, among other global challenges, extreme weather and natural catastrophe disruptions. Dow is also partnering with The Nature Conservancy to explore changes in valuing ecosystem services over the next several years. Using as a pilot site Dow's Freeport, Texas, facility, which is highly dependent upon fresh water and coastal storm surge protection, the partnership has discussed ways to increase water supply to the area and better protect the site from storm surge with cost-effective natural methods.[82]
Assessments by Insurers	**L'Oreal** works with its insurers to conduct risk audits and develop prevention plans related to the potential impact of severe storms on its operations.[83] **Merck** works with its insurers to perform an evaluation of potential risks and to take corrective actions for all facilities that are in low-lying areas or otherwise face severe weather risks.[84]

All of these approaches are capable of providing valuable information to enhance companies' understanding of potential vulnerabilities to extreme weather and climate change impacts. The approaches are not mutually exclusive and can be used in parallel or in sequence as part of a comprehensive program. The primary drivers behind which approach is selected include corporate culture, the extent to which a company has in-house risk management or scientific expertise, and the degree to which the company is in a sector vulnerable to the risks from extreme weather.

TABLE 5: Resilience Planning Resources and Tools

GUIDANCE AND FRAMEWORKS	GOVERNMENT RESOURCES
America's Climate Choices: Adapting to the Impacts of Climate Change by the National Research Council. A report that details a framework for organizations exploring adaptation, a summary of impacts observed and projected for the United States, and suggested roles for non-governmental organizations and different levels of government. United Kingdom Climate Impacts Program Adaptation Wizard and other tools. A range of tools, methods, and guidance for companies to assess and manage the risks of climate change. Climate Change Adaptation: Building the Business Case by the UK's Institute of Environmental Management & Assessment. Guidance to help environment and sustainability professionals to understand the scope and build support for the Climate Change Adaptation business case. Georgetown Climate Center's Adaptation Clearinghouse. A collection of adaptation-related resources including adaptation plans for organizations and government entities. State of Adaptation in the United States by EcoAdapt. A review of approaches and lessons learned from adaptation efforts in the United States. Appendix A lists organizations that can assist in various stages of vulnerability assessments and resilience planning. Climate Adaptation Knowledge Exchange. An online clearinghouse of case studies on adaptation efforts and contact information for practitioners. Private Sector Engagement in Adaptation to Climate Change: Approaches to Managing Climate Risks by the Organization for Economic Cooperation and Development (OECD). A report exploring companies' motivations for implementing adaptation measures and common factors that can affect companies' capacities to adapt. Industry Guide to Climate Change Adaptation by Business for Social Responsibility. A set of adaptation resources for businesses, by sector. Adapting to Climate Change: A Business Approach by C2ES. Provides a screening process that businesses can use to assess whether they are likely to be vulnerable to the physical risks associated with climate change.	U.S. National Climate Assessment (NCA) Draft Report. A draft of the upcoming comprehensive report on the impacts and responses to climate change in the United States. Climate Change, Impacts and Vulnerability in Europe 2012 by the European Environment Agency. A report presenting information on past and projected climate change and related impacts in Europe. UK Climate Projections (UKCP09). Provide future climate information projections, observed data, maps and case studies for the UK to help organizations with adaptation planning. Danish portal for Climate Change Adaptation. Denmark-based web portal that facilitates information exchange on adaptation approaches and experiences, with a specific section for business. Netherlands Route Planner. A tool that examines the likelihood of consequences arising from climate change impacts in eight sectors, giving examples of resilience strategies. New Zealand Ministry of Agriculture and Forestry's adaptation toolbox. Offers a five-step risk-based process, as well as information and resources. American Association of State Climatologists. Provide links to data and tools from U.S. state climate offices. Cal-Adapt. Adaptation resources for the state of California collected by the California Energy Commission's Public Interest Energy Research program. U.S. National Oceanic and Atmospheric Administration (NOAA) Regional Climate Centers. A combined federal-state effort delivering operational climate services. U.S. National Oceanic and Atmospheric Administration (NOAA) Regional Integrated Sciences and Assessments Centers (RISAs). Provides scenarios, projections and maps for climate impacts in the United States.

TABLE 5: Resilience Planning Resources and Tools (continued)

CLIMATE SCIENCE RESOURCES	WATER AND SEA LEVEL RISE TOOLS
SimClim Impacts and Adaptation Modeling System. A private company specializing in integrated modeling to assess climate impacts and adaptation measures. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation. A special report by the Intergovernmental Panel on Climate Change (IPCC) explores new dimensions of extreme weather risk and international efforts to address them. Fifth Phase of the Coupled Model Intercomparison Project (CMIP5). The climate models used for the IPCC's Fifth Assessment Report (AR5), scheduled for publication in September 2013, will be released in 2014. North American Regional Climate Change Assessment Program. An international program that covers the United States, Canada, and Northern Mexico and provides high resolution climate projections and scenarios. Scenarios for the U.S. National Climate Assessment (NCA). A suite of scenarios of climate, sea level rise, land use and land cover changes used for the NCA's study of potential impacts and responses for climate change in the United States.	World Resources Institute's Aqueduct Water Risk Map. A tool that measures and maps global water risk. U.S. National Oceanic and Atmospheric Administration (NOAA)'s Data Viewer. A tool for analyzing observed trends in sea level rise around the United States. U.S. National Oceanic and Atmospheric Administration (NOAA)'s Sea Level Rise and Coastal Flooding Impacts Viewer. A tool for analyzing projected sea level rise that includes visualization. U.S. Environmental Protection Agency (EPA)'s Climate Resilience and Awareness Tool. A tool to assess water risk from climate change. U.S. National Oceanic and Atmospheric Administration (NOAA)'s Sea, Lake and Overland Surges from Hurricanes (SLOSH) Model. A model developed by the National Weather Service to estimate storm surge heights resulting from historical, hypothetical, or predicted hurricanes. World Business Council for Sustainable Development's Global Water Tool. A tool to map water use and assess risks to global operations and supply chains.

STEP 3: MANAGE RISKS AND PURSUE OPPORTUNITIES

A. Managing Risks

The vast majority of companies (77) in the S&P Global 100 Index use existing risk management frameworks and business continuity processes, despite their limitations, to manage any increased risks in extreme weather. Yet a number of companies take additional steps—beyond "business as usual"—to protect against increased risks from extreme weather and climate change. The business case for taking these additional steps rested on a variety of individual company experiences and situations, including:

- Direct experience of a costly extreme weather event, such as a hurricane or flood significantly damaging a manufacturing facility, supplier, or customer
- Experience with changes in the price of key services, such as energy or insurance
- Observed changes in key inputs, for example, water supply scarcity
- Planning for investments in expensive, long-lived assets such as buildings or other infrastructure
- Having a need or desire to engage more effectively with regulators about increased climate risks (particularly common among companies in the electricity, insurance, and water industries)
- Having a corporate commitment to working with stakeholders to enhance the sustainability and resilience of key global systems, such as agriculture, forestry, or energy
- Receiving government requests for disclosure of climate change impacts and resilience activities (common in the United Kingdom)
- Perceiving opportunities for cost savings and having the goal of becoming a more efficient, competitive business under a changing environment

Companies emphasize that, given the persistent uncertainty about the nature and timing of expected impacts, decisions that are ultimately made to build greater resilience beyond standard practice or standard engineering

design criteria are not based on a single factor, but rather balance a number of considerations. Decisions to invest in equipment or facility upgrades, for example, might consider equipment condition, age, and historical performance; opportunities to improve efficiency through better technologies; or the company's ability to meet future regulations and market growth projections. It is typically a combination of drivers that triggers a management response; protection against climate change impacts can be an important additional consideration.

The types of actions that companies have taken to manage, mitigate, avoid, or transfer risks are summarized below, and specific company examples are provided in **Table 6**. Like any risk management strategy, these measures are often used in tandem to generate a portfolio of responses to address a variety of possible impacts.

Modifying planning and operational processes. Companies modify key elements of their planning and processes to better manage the increased risks from extreme weather. A number of public utility companies, for example, describe one increasingly critical element of their emergency response plans as strengthening their public outreach and communications systems to customers and regulators. Keeping customers and regulators informed of efforts to restore service tends to be a critical element in how company performance is evaluated during an extreme weather event and how costs are recuperated afterwards. Other companies, like BP and Rio Tinto, have developed separate guidance for projects or operations that help their business managers to analyze and prepare for the potential effects of climate change. Others have taken steps to build greater redundancies into critical business functions such as data centers, energy, or power supplies.

Fortifying or relocating infrastructure and facilities. Twenty-three percent of S&P Global 100 Index companies have made capital investments to fortify or harden infrastructure (roads, railways, pipelines, or energy systems) or facilities (branches, factories, ports) to enhance resilience to various climate risks. Some have even relocated entire facilities to less vulnerable areas.

Addressing volatility or changes in water supplies. Changes in water availability and quality—either from droughts or floods—are a challenge already being experienced by companies. Even S&P Global 100 companies that have not taken any steps to manage climate change risks reported that they are undertaking water management actions. Many identify water-related risk mitigation as an important priority, have goals for improving the water-efficiency of their operations, and have specific resilience plans to minimize the risks associated with this critical resource.

Managing risks within supply chains. A common risk management strategy is to diversify sources of supplies from multiple geographic locations in order to protect against a supply disruption from a particular source. Companies are taking steps to make their existing sources of supply more resilient to future extreme weather disruptions by further diversifying their supply chains geographically, increasing stockpiles of key inputs, or building greater redundancies for backup power. For some, the risks of natural disasters across a long supply chain have led to bringing production closer to home. According to one survey, two-fifths of manufacturing companies are bringing production back in-house, and a quarter have increased their use of local suppliers to mitigate interruptions from extreme weather and natural disasters.[85]

Expanding or adjusting insurance coverage. Some companies use insurance as a means of transferring risks associated with extreme events. Companies must balance the costs of insurance, which are likely to increase over time with more frequent extreme events, with the costs of taking action to reduce premiums and the potential for damages from such events.

TABLE 6: Examples of Actions Taken to Manage Vulnerabilities

RISK MANAGEMENT RESPONSE	COMPANY EXAMPLES
Modifying planning and operations	**Philips** established a security and continuity team to develop, implement, and monitor business continuity plans and technical measures (such as the availability of geographically diverse back-up systems) in order to mitigate physical climate change risks for data centers, infrastructures, and other platforms.[86] **Shell** employs a Metocean Advisor within its projects and technology team to conduct assessments of future climate change conditions for large new projects in regions such as the Arctic (projecting sea ice conditions in 2030–50), the North Sea (wave conditions in 2010-2020), and tropical areas (cyclone severity in 2010–2030).[87] **BASF** has developed contingency plans to minimize impacts associated with water levels on the Rhine River rising too high (impeding docking) or falling too low (limiting barge traffic).[88]
Fortifying or relocating infrastructure and facilities	To help resolve ongoing challenges with severe water scarcity in Kentucky, which may further intensify with climate change, **American Water** constructed a $164 million water treatment plant to help ensure adequate water supply to the region.[89] IT hardware company **EMC** estimates that it spends $10 million annually to ensure its data centers are located in areas less vulnerable to extreme weather and to build a more resilient, diversified business infrastructure.[90] As part of its 2004 to 2008 restructuring program, a number of **Colgate's** almost 60 manufacturing sites were closed around the world, some of which were being increasingly exposed to severe weather conditions such as hurricanes and coastal or river flooding. Site locations for newly constructed facilities reduce the company's overall exposure to severe weather conditions of the type projected to occur according to the IPCC. The company believes it has either eliminated risk exposure at sites (by selecting different locations) or mitigated it (by shoring up sites where appropriate).[91]
Addressing volatility or changes in water supplies	Using the WBCSD's Global Water Tool, **3M** has identified 18 sites (out of over 200) located in water-stressed areas and requires each of these sites to assess its water use and risks and to develop a water conservation plan.[92] **General Motors** is enhancing its resilience by reducing the water intensity of its global operations by 15 percent by 2020. Its recently constructed facility in a water-stressed area in Mexico was designed with a zero-discharge concept in which almost all—90 percent—of wastewater is reused for sanitary, cooling tower, and irrigation systems.[93]
Managing risk within supply chains	**PepsiCo**. is working with a Mongolian potato farm that supplies ingredients for Frito-Lay chips to achieve water savings of 30 percent by installing more water-efficient and reliable water systems than the flood watering that formerly hydrated fields. The firm is also exploring drip irrigation systems that use 50 percent less water than traditional farming methods.[94]
Expanding or adjusting insurance coverage	**Kimberly-Clark** addresses many of the risks associated with extreme weather through the purchase of insurance, which covers property damages and business interruption at Kimberly-Clark facilities. Its insurance also covers some of its suppliers if affected by a covered event.[95]

B. Pursuing Opportunities

S&P Global 100 companies are increasingly aware of not only the risks associated with changing climate but the business opportunities that such changes would create. Three primary types of activities designed to take advantage of opportunities are summarized below, and specific company examples are provided in **Table 7.**

Serving new demands for existing products. Companies are exploring ways in which the demand for existing products may grow, as customers—existing and new—prepare for or cope with the impacts of extreme weather and climate change impacts.

Improving efficiency and reducing costs. More efficient use of resources, especially energy and water, can provide benefits to companies and their customers. Targeting energy or water conservation, for example, would mitigate the impact of an interruption in supply and reduce costs. Weather-related risk mitigation efforts at

facilities might be rewarded by insurers through reduced premiums. More frequent types of extreme weather or changes in climate conditions can often amplify these benefits. In general, several companies stated that making their operations or supply chain more resilient to extreme weather and climate change would generate a competitive advantage.

Developing new products and services. Extreme weather and other climate change impacts are likely to create new markets and demands for new types of products. Companies are investing in improving their understanding of the emerging needs of potential customers, in preparing for the competitive landscape of these new markets, and in engaging in research and development.

TABLE 7: Examples of Business Opportunities

OPPORTUNITIES	COMPANY EXAMPLES
Serving new demands for existing products	Switzerland-based **Holcim**, one of the world's leading suppliers of cement and aggregates, anticipates that more severe storms and floods will mean greater demand for stronger and more resilient building materials and for protective infrastructures such as floodwalls in particular. Holcim is working through trade associations, such as the National Ready Mixed Concrete Association, to help educate customers and regulators about the cost-effectiveness of building with durable materials.[96] **GE** is growing the markets for its water technologies—from wastewater treatment and reuse technologies to desalination equipment—for use in power plants, agriculture, and manufacturing. These technologies will serve an expanding international market, as limited water supplies in India and China will likely begin to impede those countries' plans to build more new power plants.[97] Globally, spending on water infrastructure is expected to grow from $90 billion in 2010 to $131 billion in 2016, and sales of water- and wastewater-treatment equipment to industrial users is expected to rise from $14 billion in 2010 to $22 billion by 2016.[98] GE expects revenues from its water recycling technologies to grow by about 10 percent annually through at least 2016.[99]
Improving efficiency and reducing costs	**American Water** is bringing its water conservation solutions and know-how to its some of its largest customers. The company's Environmental Management Corp. provides technologies and operates water and wastewater systems on a contract basis to help industrial customers treat and re-use wastewater. The company's Innovation Development Program is also exploring new technologies that will enhance water efficiency, promote water conservation, and expand water supply in innovative ways. The Program's mission is to identify, develop, and help deploy technologies that will both enhance the company's own efficiency and open up business growth opportunities for serving customers.
Developing new products and services	**GE** has been working on a Water Risk Atlas with Goldman Sachs, the World Resources Institute, and others to map water-related risks for companies, investors, governments, and stakeholders. This database will help GE and other companies to identify markets for their more efficient technologies where climate change is leading to water scarcity and stress on water resources. In 2011, **Weyerhaeuser** established subsidiary Weyerhaeuser Solutions to leverage its long experience with managing large land holdings to help other industries—energy, chemicals, materials and mining, agriculture, manufacturing, government—with interests in large-scale land holdings. The idea for the service emerged from conversations with businesses about climate change and their increased interest in implementing sustainable forestry practices on company-owned land or investing in sustainable forestry projects. Such new business opportunities are identified through the company's periodic direction-setting sessions, which consider the impact of future trends and alternate scenarios on the business.[100] **Bayer** MaterialScience estimates that around 20 percent of its $9.7 billion revenue in 2011 came from climate-related business, and that rising temperatures and more severe storms will increase demand for better insulation and stronger building materials. Bayer is investing in new products and expanding its research partnerships on enhancing crop productivity and resilience to weather stresses, high-performance insulation materials that lend enhanced stability to buildings exposed to severe storms, and mosquito nets that offer better protection against malaria.[101]

STEP 4: ASSESSMENT AND REVIEW

Given the complex nature of physical climate change risks, companies should develop strategies that are themselves adaptive and help build business resilience or flexibility to respond over time.

Given the uncertainty around predicting future climate conditions, companies recognize that robust risk management approaches require a risk management process that is iterative. Companies are utilizing periodic due diligence and review cycles within their established enterprise risk management systems to regularly reassess climate risks. Risks are considered in an ongoing manner within one or more of the following:

- Approval of new capital and operations and replacement expenditures
- Siting and design of new facilities
- Purchase of insurance and other risk transfer mechanisms
- Selection of suppliers, and the requirements that suppliers should meet
- Development and monitoring of resilience plans at facilities deemed most vulnerable

Given the complex nature of physical climate change risks, companies need to begin to develop strategies that are themselves adaptive and that help build business resilience or flexibility to respond over time **(Box 9)**. The best practices for managing risk evolve as companies learn more about the nature of their vulnerability. To support this institutional flexibility, companies need to begin today to establish the capacity to monitor how extreme weather events and future climate conditions affect their business performance.

Currently, there are few standardized metrics of vulnerability or resilience to extreme weather or climate change impacts that have been applied to business operations. Some companies choose to devise new metrics that represent facility-, region-, or enterprise-scale vulnerability or resilience. However, it is potentially more useful to explore how existing performance metrics can be adapted to yield a meaningful picture of vulnerability and resilience. Examples of metrics adaptable to the challenges and uncertainties of climate change could include typical efficiency or sustainability metrics (e.g., energy and water use, and energy and water intensity), revenue losses or recovery times associated with service disruptions, probability of threshold failures, or metrics related to diversification among suppliers, investments, or assets.

Box 9. Adaptive Management Practices at Weyerhaeuser

Weyerhaeuser manages over 20 million acres of timberland around the world. It has more than a century of experience with understanding the impacts of weather and climate on forests, and managing those to maximize yield. The company's continual risk assessment and adaptive management processes have been critical for building its resilience to the effects of climate trends and extreme weather. Incorporating future climate change scenarios and factors into these processes only reinforces to Weyerhaeuser the importance of its existing efforts and approaches. For example, in Weyerhaeuser's Timberlands business, a centralized strategic planning group uses geographic- and species-specific forecasting models and sensing technologies to examine the relationship of local and regional climate changes to long-term forest growth and yield. The company's in-house staff of hydrologists, plant pathologists, and other experts conducts extensive research on the ground to collect real-time environmental data, and key findings are incorporated into central planning models.

For much of its risk management analysis, Weyerhaeuser relies on close monitoring of existing conditions that impact its timberlands. This continual risk assessment process provides an early indication of changes in the growing environment, enables the company to assess possible vulnerabilities to shifts in climate, and guides its responses and adaptive management practices. Over time, Weyerhaeuser has developed robust management responses to build resilience across the growing cycle of its timberlands—from planting to final harvest—against losses from storms, pests, wildfires, and drought. The company regularly updates its forest timber inventories, growth projections, harvest schedules, and planting activities to account for potential and actual annual losses from extreme weather. This information is also used by the company in locating new forestlands in favorable geographies with incidence rates of storms, drought, and fire that are manageable, both now and in the decades ahead.

V. ROLE OF GOVERNMENT

Companies face significant barriers when making decisions about how and when to invest in enhancing their resilience to climate change. While overcoming these barriers is largely an internal challenge, there are a number of steps that governments can take to facilitate these corporate efforts. They can provide and coordinate efforts around climate change research, enhance the resilience to weather extremes of critical public infrastructure, and advance and approve resilience planning in regulated sectors such as water, electricity, and insurance.

PROVIDE CREDIBLE, READILY ACCESSIBLE SCIENTIFIC INFORMATION, MODELS, AND TOOLS

Companies clearly need government agencies to provide more comprehensive and detailed data and tools related to climate change impacts. Governments can help provide the basic scientific observations, research, modeling, and tool development that are critical to supporting business decisions.

The United Kingdom provides a good example of the role that governments can play in collecting data, directing and coordinating research studies, and translating findings into user-friendly tools and resources for business. Since 1997, the UK government has pursued an aggressive national program to better understand and manage the risks of extreme weather and climate change. The UK Climate Change Act of 2008 directs companies with "functions of a public nature" (such as water and energy utilities) to report on how they are assessing and acting on the risks and opportunities from a changing climate. To assist companies in this effort, the UK Met Office (the national weather service) acts as a "one-stop shop" of information and assistance on climate and weather. The UK Climate Impacts Programme (UKCIP), established by the government in 1997, coordinates national research and tools that companies can use to evaluate and manage impacts (**Box 10**). The UKCIP has developed climate change projections to help companies test their resilience to a range of future conditions. The scenarios provide both historical and projected information to 2100 for the UK, based on climate change simulations from the Met Office's Hadley Research Centre. The scenarios include observed 20th- and 21st-century data about temperature, precipitation, storms, sea surface temperatures, and sea level; future projections for temperature, precipitation, air pressure, clouds, and humidity; and projections for sea level rise,

Box 10. Resilience Planning: National Grid's Leadership in the UK

National Grid has served as a partner in the UK government's initiative to assess climate change risks to natural gas and electricity systems. It works directly with the government to evaluate risks and is taking a leadership role in helping to prepare the energy sector for impacts expected through the end of this century. National Grid has studied the impacts of a changing climate since 2006 with the support of the UK Met Office and the UKCIP. National Grid and other UK energy companies also commissioned the Met Office to conduct a qualitative assessment of potential impacts. One of the key outcomes was a study released in 2008 that integrated climate change science and modeling tools with a risk-based business planning process over a 15- to 40-year timeframe for energy asset investments. Among the issues investigated are the impact on cables from changes in soil conditions, how urban heat islands might affect power and gas infrastructure, and extreme weather effects on the resilience of electricity networks. They also developed a tool to predict sea-level surges and models of wind projections. Starting in 2010, National Grid used the UKCIP climate change projections to evaluate the resilience of its assets and business practices. It converted information from the scenarios on temperature, rainfall, and sea level rise; Met Office studies on the energy sector; and insights from its own engineers into a set of "Specific Physical Characteristics" that could pose risks to the company.

storm surge, sea surface and sub-surface temperature, currents, and waves.

In the United States, the National Climate Assessment (NCA) is undertaking a major ongoing initiative aimed at providing the public and companies with critical information about observed and potential future changes in our climate.[102] The NCA has involved the business community to better understand their needs, and is committed to providing ongoing information about the impacts of extreme weather and climate change. In 2011-2012, the NCA held a series of sector-specific and regional workshops to gain input from interested parties and will be issuing a major assessment at the end of 2013. The draft report released in January 2013 addresses key sectors affected by climate change (e.g., water resources, energy, transportation, agriculture, coastal development) and provides detailed assessments of climate change impacts in eight regions of the United States. The report and web-based materials developed by the NCA also provide up-to-date scenarios of future climate change that can be used by companies and communities to assess their vulnerabilities and manage risks. While current efforts provide important information to the business community, an enhanced public-private partnership, similar to the UKCIP's activities, would advance efforts in the United States to help companies to evaluate and manage climate-related impacts (**Box 11**).

Appendix C provides a list of resilience planning resources available to the private sector from governments.

ENHANCE THE RESILIENCE OF PUBLIC INFRASTRUCTURE

Companies face a broad range of potential impacts that are not directly within their control but which can have significant impacts on the losses they suffer from extreme events and impacts associated with climate change. Extreme weather events frequently damage critical elements of public infrastructure—roads, bridges, ports—that are important to company operations. Governments need to play a stronger role in managing this infrastructure through:

- Developing standards for its location, design, and maintenance
- Utilizing zoning to address land use conflicts and manage risks, particularly in coastal and floodplain areas
- Maintaining transportation routes along rivers and at ports
- Managing flood and crop insurance programs

Box 11. Advancing Business Resilience Planning: Proposals for New Voluntary Partnerships

While there is growing recognition among companies that extreme weather and climate change impacts are financial risks that can no longer be ignored, current efforts are largely ad hoc and insufficient. To enhance efforts in the United States, a new national voluntary program could be developed as a public-private partnership to bring together the expertise that exists across the federal government to work with companies interested in developing or enhancing their resilience plans. This effort would be patterned after the many voluntary programs that exist across the federal government to encourage action on other environmental challenges.[103] These resilience planning partnerships would serve the dual purpose of providing federal expertise for companies in undertaking updated risk management strategies, while better informing the federal government of the data and tools needed by the private sector. Such a program could identify best practices and recognize those companies that have implemented exemplary plans.

Another vehicle for facilitating collaborations between business and government could entail public-private partnerships between relevant government agencies, for example the Department of Energy, and industry-sector trade associations. Sector trade associations have long played an important role in developing tools and methods (e.g., standards, work practices, and guidelines) that allow individual companies across the sector to meet their corporate objectives. Given that the clusters of issues related to extreme weather and climate change impacts tend to be common to a sector, it may be far more efficient for government agencies to work cooperatively through trade associations to coordinate with companies to meet data requirements and develop analytical tools for managing these risks. Companies would then be free to decide how to apply these tools—maintaining confidentiality and avoiding any issues related to competitiveness.

that send property owners the signal to minimize climate risk

- Maintaining critical natural resources (e.g., sand dunes, wetlands) that can act as buffers against storms
- Enhancing and adding redundancies to communications systems, including early warning systems
- Upgrading major water supply infrastructure (e.g., dams, irrigation lines)
- Providing funds for and directing emergency response and rebuilding efforts following extreme weather events

These beyond-the-fenceline responsibilities that fall squarely within the purview of governments can significantly affect the level of damage sustained by companies and how quickly they are able to resume operations. Over time, it will be important for all levels of government to more fully incorporate resilience planning into their activities to safeguard the public infrastructure critical to the well-being of companies and the broader economy.

ADVANCE RESILIENCE PLANNING IN REGULATED SECTORS

Regulated companies, such as those that provide water, electricity, or insurance, often are hit particularly hard by extreme weather, and yet their efforts and related expenses to become more resilient must generally be approved by government rate commissions In the case of water and electric utilities, these commissions have as their primary objective ensuring the safe, affordable, and reliable provision of these key commodities. Regulated water and electric utilities that seek to spend resources on enhanced resilience often must make a compelling case that the dollars to be spent are justified and will benefit ratepayers through systems more capable of holding up to severe weather as well as the longer-term changes in a region's climate.

The pricing of water resources in parts of the country faced with increasing scarcity represents another challenging situation **(Box 12)**. Where water allocations are set by governments and prices often fail to reflect the growing scarcity, it is difficult for companies to financially justify decisions that promote more resilient operations. The relatively low prices do not reflect the situation of high demand and low supply, yielding the water utility inadequate revenues with which to fund resilience measures. In addition, efficiency programs designed to reduce water usage can also reduce water proceeds, which make it even more difficult for water providers to pay for infrastructure upgrades. It is critical

Box 12. American Water: Planning for a Changing Climate at the U.S.'s Largest Publicly Traded Water Utility

American Water provides drinking water, wastewater, and related services to approximately 14 million people in more than 30 states and in Canada. Its core risk management and investment planning strategies require making projections about future water availability under uncertain and variable weather conditions. American Water anticipates greater uncertainty and risk under changing climatic conditions and is therefore adopting a more integrated management approach to water resources that will expand available water supply options through more water conservation and re-use—an approach that it implemented only on a sporadic basis in the past. American Water's integrated water resource management plans look holistically at the water cycle, to consider, for example, the availability and use of alternative or distributed water supplies.

Support from U.S. state and federal regulators is critical for the company to achieve these risk management objectives. For many state regulators, especially in water-stressed states such as Texas, California, and Arizona, water conservation is a way of life. Regulators in California, for example, have implemented "conservation pricing" that decouples the price of water from the amount of water that people use, which helps utilities justify investing in efficiency and conservation. Regulators in Pennsylvania, New Jersey, Indiana, and Illinois are beginning to explore the costs and benefits of water conservation tariffs.

American Water has already seen a 10 percent reduction in water use over the past ten years, mainly attributable to U.S. Department of Energy regulations requiring more stringent standards for low-flow toilets and fixtures. The company believes that, with the right policies, there are significant opportunities over the next 50 years to improve the efficiency and resilience of U.S. water and wastewater infrastructure.

that these regulatory entities be forward-looking and open to companies making the case for increased spending on resilience.

Resilience planning in the insurance sector can also play an important role in addressing the impacts of extreme weather and climate change. Private insurance can create important financial incentives that encourage parties to enhance their resilience and more effectively manage risks. Insurance premiums should fully reflect the risks of extreme weather and climate change impacts and can provide incentives for insured parties to take actions to become more resilient by offering reduced premiums.

Private insurers face issues similar to those of regulated utilities—they must work through state regulators to obtain premiums that accurately reflect current and future risks, including the increased risks from extreme weather and a changing climate **(Box 13)**. This involves making a strong analytical case that increased risks of extreme weather are quantifiable and can be predicted with reasonable certainty. Without detailed, empirical data, however, it remains difficult for the insurance industry to make a compelling case to state regulators about appropriate levels of insurance coverage and pricing of climate change factors into insurance products.

Box 13. The Hartford: Insurance on the Front Lines of Managing Risks

Insurers are some of the first companies to recognize emerging risks, and many are at the forefront of examining changes in weather and climate risk. The Hartford, a leading U.S. property and casualty insurer, has assessed the impact of weather risks from hurricanes, fires, snowstorms, and other events on its individual and commercial policyholders for decades. Having witnessed the effects of increasing climate variability over the past five to 10 years, it expects that underwriting costs will continue to rise with increasing damages from extreme weather.

The Hartford, along with its industry peers, has been a strong advocate at both the state and federal level on public policy solutions that:

1. Ensure that insurance rates reflect the real costs of weather risks so that they can guide property owners' decision-making and encourage sufficient levels of risk mitigation
2. Reduce overall societal exposure to climate change through improved land-use planning and public-sector mitigation efforts, especially along the coasts
3. Provide for self-sufficient insurance mechanisms within the states to reduce public subsidies that have the potential to exacerbate the growth in exposures at risk from climate change

VI. CONCLUSIONS

While the effects of climate change bring some new opportunities for companies, they primarily create new challenges. Extreme weather events can bring destruction both directly, in terms of human lives, property damage, and economic disruption, as well as indirectly through large-scale resource scarcity and stresses on customers and communities.

Some companies and industries are more at risk than others, but all will experience these impacts. Many companies are preparing now to capture the competitive advantages that accrue from more effectively managing these risks. They are building the capacity to learn from the incremental steps that they are taking to build resilience over time. In many ways, building resilience is doing what companies have always done—strategic planning, risk assessment, investing in infrastructure, diversifying the supply chain, safeguarding employees—using the most up-to-date information available about risks. But in today's world, building resilience requires paying much closer attention as information and experiences about the impacts of climate change accumulate and are refined. Over the long term, the companies most able to adapt their operations and offerings to these new conditions will likely be the most competitive.

The perceptions, activities, and barriers to action of leading companies center around the following key themes:

- *Companies are generally aware of the risks, but few are yet taking sufficient forward-looking action.* While most companies have established business continuity or emergency preparedness plans, few have incorporated the increased risks associated with more frequent or intense extreme events associated with climate change.
- *A major barrier preventing many companies from taking action is uncertainty around the scope and nature of the risks.* Many companies find it challenging to integrate factors involving physical climate change into corporate risk management because it is difficult to sufficiently quantify the precise nature and timing of extreme weather and climate change impacts, and they lack the tools to incorporate these changes into their corporate decision-making.

A growing number of companies are recognizing that they must take action now to more effectively manage these risks. An initial set of practices emerged from companies that are already taking action. Key elements of an effective risk management strategy to address extreme weather and climate change include:

1. *Build awareness of the changing risks of extreme weather and climate change.* It is critical that companies begin now to build a common base of understanding of the physical risks associated with extreme weather and climate change, and their potential impacts across the business, including operations, facilities, supply chains, employees, customers, and community engagement.
2. *Assess vulnerabilities.* Companies need to expand their conventional business risk assessments to identify the extent to which any recent weather extremes adversely impacted their facilities and operations, and assess the impacts that future changes in the risks of such events could have. These risk assessments need to take place as part of the company's overall business risk strategy, either directly integrated into core risk management processes or as a climate change risk "filter" or "overlay" to existing risk management frameworks.
3. *Outline strategies for managing risks and opportunities.* Companies need to prioritize options and adaptive measures, and integrate these into enterprise-wide risk management systems. Once potential impacts are identified—both positive and negative—companies must develop plans to prioritize actions to manage the risks and maximize the opportunities. It is critical that companies work across their value chains, within and beyond their industry sectors, and with local governments and stakeholders to ensure that actions taken will build in an appropriate level of resilience. Building resilience may require the participation of a wide range of stakeholders, each with its own interests

and timeframes; in some cases existing policies may present challenges.

4. *Continually assess and review.* Companies need to ensure that risk management planning is adaptive over a range of impacts over time. By incorporating the risks of physical impacts into their ongoing risk management activities, leading companies are regularly updating their understandings of risks and the necessary responses as new information becomes available. They are committed to laying the groundwork for learning and developing resilience strategies and capacities over time.

The unusual challenges for businesses brought by the risks of extreme weather and climate change impacts make the support of national and local governments a necessity. Governments must help to provide the basic scientific observations, research, modeling, and tool development that are critical to supporting business decisions. Governments also play a significant role in managing public infrastructure—roads, bridges, ports—and public resources—water and land—that are critical to company operations. Governments must invest in maintaining these infrastructures and set standards for better management of critical natural resources. It is also critical that regulatory entities be forward-looking and open to companies making the case for their increased spending on resilience, particularly in such regulated sectors as insurance, water provision, and electric utilities.

Leading companies are beginning to take steps to build resilience to the physical effects of climate change. While uncertainties exist about precisely *how* climate change will manifest over the coming years and decades, and how its impacts will vary geographically, leading companies are recognizing that waiting to act can be a costly response.

APPENDICES

APPENDIX A. NOTES ON METHODOLOGY

C2ES undertook a three-part research effort to understand how companies are addressing the physical risks of extreme weather and climate change.

I. Assessment of public statements by the companies comprising the S&P Global 100 Index. (Companies are listed on the following page.) C2ES did a systematic review of these 100 companies' statements about climate change and its predicted risks to their operations, using three publicly available sources.

1. *Responses to the Carbon Disclosure Project (CDP) 2012 Investor Survey*. Completed by 94 of the S&P Global 100 Index companies, Questions 5 and 6 of this survey ask companies whether they have acted to address the physical impacts of climate change. We also analyzed responses to the CDP 2011 Water Disclosure survey, answered by 47 of the 100 companies, since water scarcity issues are often thought of as a proxy for climate change impacts.

   Questions 5 and 6 of the 2012 CDP survey were the following:

   5.1. Have you identified any climate change risks (current or future) that have the potential to generate a substantive change in your business operations, revenue, or expenditure?

   5.1c. Please describe your risks that are driven by changes in physical climate parameters.

   5.1d. Please describe (i) the potential financial implications of the risk before taking action, (ii) the methods you are using to manage this risk, and (iii) the costs associated with these actions.

   5.1h. Please explain why you do not consider your company to be exposed to risks driven by physical climate parameters that have the potential to generate a substantive change in your business operations, revenue, or expenditure.

   6.1. Have you identified any climate change opportunities (current or future) that have the potential to generate a substantive change in your business operations, revenue or expenditure?

   6.1c. Please describe the opportunities that are driven by changes in physical climate parameters.

   6.1d. Please describe (i) the potential financial implications of the opportunity, (ii) the methods you are using to manage this opportunity, and (iii) the costs associated with these actions.

   6.1h. Please explain why you do not consider your company to be exposed to opportunities driven by physical climate parameters that have the potential to generate substantive change in your business operations, revenue, or expenditure.

2. *Financial Disclosure Forms from 2011.* In their financial filings, publicly traded companies are required to identify the risks that could have a "material adverse effect" on their businesses.[104] Some jurisdictions (e.g., the UK) require a greater level of corporate disclosure on climate-related impacts in financial filings than other countries (e.g., the United States). C2ES assessed whether S&P Global 100 Index companies discussed physical climate change risks in their 2012 annual financial filing reporting on year 2011 activities (i.e., SEC Form 10-Ks for U.S.-headquartered companies and SEC 20-F, SEC 40-F, or Annual Reports for foreign companies) and ranked them on a scale of 1 to 5. A score of 1or 2 indicated that the company did not substantially identify risks from climate change impacts. These companies either did not mention climate impacts or extreme

weather risk at all (beyond a standard sentence about catastrophic risks) (53 companies) or mentioned extreme weather or water scarcity as a risk without describing the increases in those risks from climate change (11 companies). A score of 3, 4, or 5 was considered an adequate discussion of risks. These companies reported the physical effects of climate change as a business risk (though often noted that the precise effects were uncertain) (15 companies), some companies described a specific physical impact (such as floods or warmer temperatures) as a concerning business risk (9 companies), and a few described a specific action they were taking to better understand or mitigate the risk (12 companies).

3. *Company Sustainability Reports from 2012.* We reviewed 2012 corporate sustainability reports (available for 97 of the 100 companies) to identify any statements related to impacts or actions associated with the physical effects of extreme weather and climate change.

II. **Case Studies.** To delve more deeply into specific ways that companies address the physical impacts of climate change, C2ES conducted in-depth interviews with six companies representing six sectors: American Water, Bayer, National Grid, Rio Tinto, The Hartford Group, and Weyerhaeuser. This process involved a review of public information on the company and telephone interviews with multiple staff involved with corporate climate change issues. In addition we interviewed several companies, including Holcim, Entergy, and Dow, on specific aspects of their resilience efforts.

III. **Workshop on Business Resilience.** In November 2012, C2ES organized a workshop involving 40 participants representing 23 companies and 7 other organizations, including experts from the National Oceanic and Atmospheric Administration (NOAA) and the National Climate Assessment, to explore particular challenges and opportunities for building business resilience. This information was supplemented with follow-up conversations with staff at the companies and with selected reports on the topic released by other organizations.

Companies in the Standard & Poor's (S&P) Global 100 Index on May 30, 2012

3M Co.
ABB Ltd.
Aegon NV
Alcatel-Lucent SA
Allianz SE
Anglo American Plc
AstraZeneca Plc
Aviva
AXA
Banco Bilbao Vizcaya Argentaria SA
Banco Santander SA
Barclays
BASF SE
Bayer AG
BHP Billiton Ltd.
BP
Bridgestone Corp
Bristol-Myer Squibb
Canon Inc.
Carrefour SA
Caterpillar Inc.
Chevron Corp.
Citigroup Inc.
Coca-Cola Co.
Colgate-Palmolive Co.
Credit Suisse Group AG
Daimler AG
Dell Inc.
Deutsche Bank AG
Deutsche Telekom
Diageo Plc
Dow Chemical
DuPont, E.I. de Nemours
E.ON AG
EMC Corp.
Ericsson, L.M. Telefonaktie
Exxon Mobil Corp.

Ford Motor Co.
France Telecom SA
Fujifilm Holdings Corp.
GDF Suez
GE
GlaxoSmithKline
Goldman Sachs Group Inc.
Honda Motor Co.
HP
HSBC Holdings Plc
IBM Corp.
ING Groep NV
Intel Corp.
Johnson & Johnson
JP Morgan Chase & Co.
Kimberly-Clark
Koninklijke Philips Electronics NV (Royal Philips Electronics)
L'Oreal
LVMH-Moet Vuitton
McDonald's Corp.
Merck & Co. Inc.
Microsoft Corp.
Morgan Stanley
Munich Re AG
National Grid PLC
Nestle SA
News Corporation
Nike Inc.
Nissan Motor Co.
Nokia OYJ
Novartis AG
Panasonic Corp.
PepsiCo Inc.
Pfizer Inc.
Philip Morris International
Procter & Gamble
Repsol-YPF SA
Rio Tinto Plc
Royal Dutch Shell PLC
RWE AG
Saint-Gobain, Cie de
Samsung Electronics Co.
Sanofi-Aventis
Schneider Electric SA
Seven & I Holdings Co. Ltd.
Siemens AG
Societe Generale
Sony Corp.
Standard Chartered
Swiss Re
Telefonica SA
Texas Instruments Inc.
Toshiba Corp.
TOTAL SA
Toyota Motor Corp.
UBS AG
Unilever NV
United Technologies Corp.
Vivendi
Vodafone
Volkswagen
Wal-Mart
Xstrata

APPENDIX B. UNDERSTANDING THE SCIENCE LINKING EXTREME WEATHER AND CLIMATE CHANGE

For a company experiencing electricity outages, supply disruptions, or inundated facilities, the question of whether the event was "caused" by climate change has little relevance in the moment. Once disaster strikes, all that matters is safety, restoring power, and getting facilities up and operating. But companies are also invested in effectively managing these risks, and from this perspective it is important that they understand and plan for the full range of possible extreme weather in the coming years. Historically, companies planned on the assumption that, when it comes to weather, the past is prologue to the future—that future climate would be the same as that in the recent past. However, given our current science-based understanding of climate change, companies should be incorporating more forward-looking information in order to fully reflect how the risk profile of extreme weather events is shifting.

Climate change is often perceived as a slow, gradual change in mean temperatures. However, a relatively small change in average temperatures results in large increases in the risk of extreme heat and substantial decreases in the risk of cold weather, a pattern reflected in changes being currently observed in temperatures in many locations across the globe (**Figure B1**). This recent change in the frequency of some types of extreme events is an important early warning to companies that climate change is not just about long-term impacts, but is beginning to impact their bottom line today.

Understanding of the link between different types of extreme weather and climate change is an important first step in companies' assessing how their risk profile is changing. In general, scientists require three separate lines of evidence before declaring a type of extreme weather to be related to climate change. First, *basic physics* must show that climate change is capable of affecting the frequency or intensity of a given type of weather event (e.g., a warmer atmosphere holds more water which can lead to heavier rainfall events). Second, *models* assuming higher greenhouse gas concentrations should show changes in the frequency or severity of a given type of weather event compared to models without higher concentrations. Third, *observational records* should show a shift in the occurrence of the weather event over recent decades (e.g., the number of new high temperatures over the past several years far exceeds the number of new low temperatures recorded).

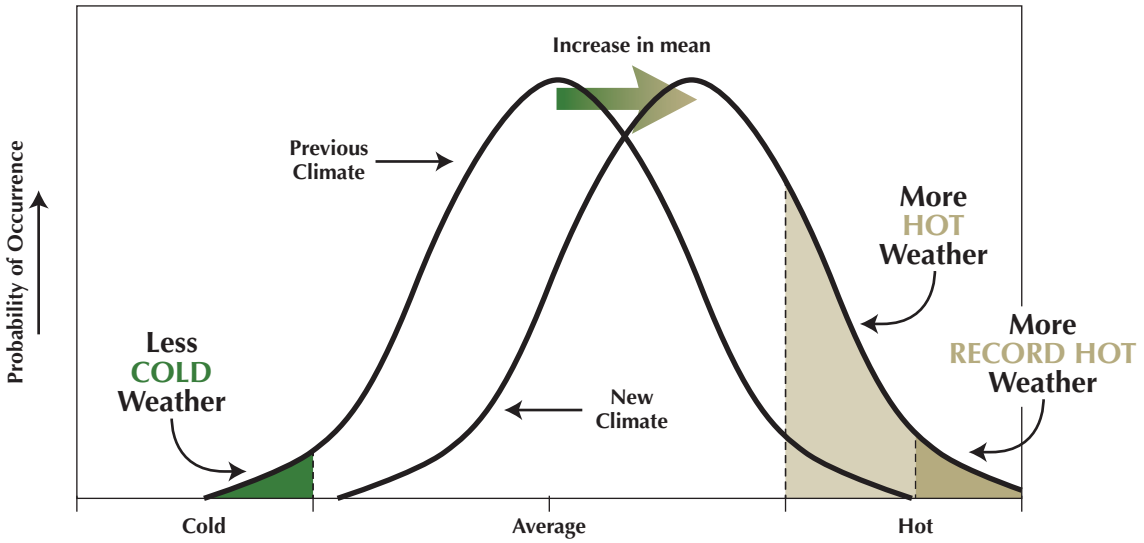
For heat waves, droughts, wildfires, and heavy precipitation, all three avenues of evidence are in strong agreement. For hurricanes, the evidence is somewhat mixed. The scientific evidence suggests that an increase in severity is likely, but there is some evidence that the *number* of storms may decrease. For tornadoes, the question of a link between their severity or frequency and climate change has not been established.

By definition, climate is the average of individual weather events over many years, and to speak of any single event as being "caused" by climate change is incorrect. The impacts of climate change on extreme weather are most accurately characterized in terms of changes in risk of such events occurring. The climate system is fundamentally probabilistic: climate change is increasing the odds of many types of extreme weather—trends that can be seen in the data over recent decades, centuries, and millennia. The relationship between extreme weather and climate change can be seen using the analogy of the link between a baseball player's performance and his use of steroids.[105] Before beginning to take steroids, a given player was capable of hitting home runs and in fact occasionally hit one. After taking the drug, he hit more home runs. As a result of being on steroids, his chances of hitting a home run with any given pitch? have increased substantially. Can any particular home run be said to be caused by the player being on steroids? No. But the probability of his hitting a home run went up. The relationship between increases in greenhouse gases and extreme weather works in the same way: the probability of an extreme weather event increases with higher levels of greenhouse gases in the atmosphere.[106]

Figure B2 illustrates the increase in meteorological, hydrological, and climatological catastrophes worldwide from 1950 to 2011. The figure shows that the total number of such events in any given year can vary substantially, with an overall trend of very damaging events increasing over time.

Sea level rise is the other primary area of concern for businesses related to the physical impacts of climate change. Global sea level has increased by about 8 inches above preindustrial levels. Estimates of future changes in sea level have increased over time as contributions from melting land-based sea ice have risen. Current estimates suggest increases on the order of 2 to 5 feet by 2100.[108]

FIGURE B1: Increase in Mean Temperature and More Changes in Extreme Temperatures



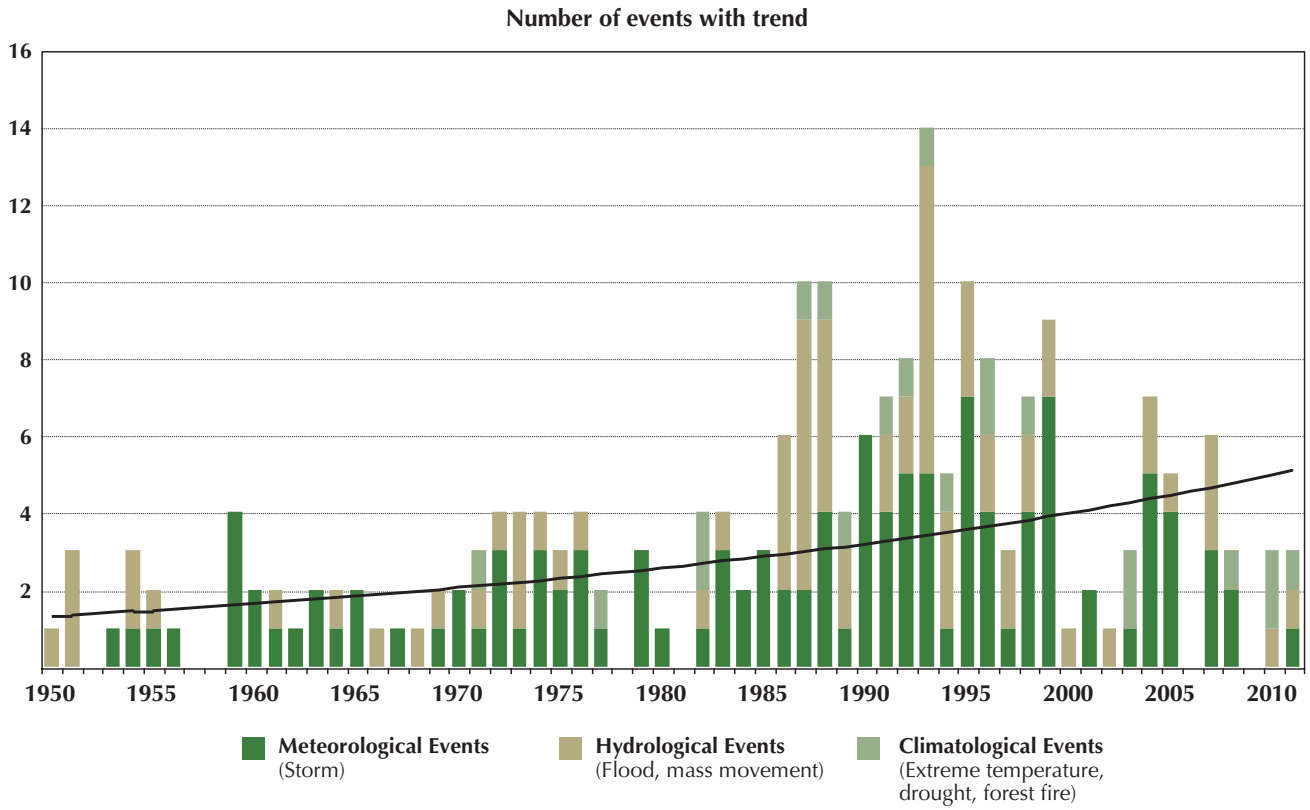
Climate change shifts the odds for extreme weather events.
Source: Solomon et al., IPCC (2007).

Sea level rise, when combined with coastal storm surges and high tides, can vastly increase the risk of coastal flooding, making previously rare flood levels much more common. From the perspective of business resiliency, sea level rise must be considered in terms of the vulnerability of operations and facilities along the coast that become more directly at risk from storms, increased storm surge, and salt-water intrusion. These facilities may also be more indirectly at risk from the loss of critical infrastructure—such as transportation infrastructure and water and electricity systems—during and following floods.

Businesses may also be vulnerable to extreme weather and "natural" climatic variations that are not directly enhanced by climate change. For example, strong El Niño and La Niña events can influence the geographic distribution of precipitation (both snow and rain), the occurrence of heavy rainfall events, and the frequency of cold air outbreaks in many parts of the country. These "natural" events have had significant impacts on businesses, especially those associated with water supplies and agriculture. As such, they should be included in risk management, regardless of the causal connection to climate change.

Finally, it is important to fully consider the context in which the changing risk profile of extreme weather and climate change is taking place. In many cases, climatic changes can be amplified by non-climate factors (increases in population, competition for scarce resources, changes in land use) that make companies' facilities and operations more vulnerable to the changing risk profile associated with climate change. For example, past assumptions about flooding may no longer hold once more of the surrounding area has been developed and paved. Increased demands on water resources in the western United States will likely amplify the adverse impacts caused by future droughts. In fact, precipitation amounts that were once considered "normal" may not be sufficient to meet current and future demands. Within their risk management strategies, companies must incorporate these types of changes in non-climate factors that affect vulnerability, especially those factors that can exacerbate impacts related to climate change.

FIGURE B2: Major Weather Catastrophes Worldwide, 1950–2011



Source: Munich Re (2012).[107]

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CASE STUDIES

CASE STUDY: AMERICAN WATER

CASE STUDY	AMERICAN WATER
Headquarters:	Voorhees, New Jersey
Industry:	Water Utilities
Revenues (2012):	$2.7 billion
Employees:	6,700
Key Initiatives:	• Conducting climate change sensitivity analyses of capital planning decisions • Building greater redundancies into energy supply and communications systems • Developing innovative water management practices and technologies

COMPANY PROFILE

Founded in 1886, American Water is the largest publicly traded water and wastewater utility company in the United States, providing drinking water, wastewater, and other related services to approximately 14 million people in more than 30 states and Canada. With headquarters in Voorhees, New Jersey, the company employs approximately 6,700 people and supplies its customers through a vast network of treatment plants, pumping stations, storage facilities, and approximately 45,000 miles of main and collection pipes. The company principally serves residential homes and businesses, and also performs non-regulated contract operations for municipalities that own their utility systems. Additionally, American Water develops and implements solutions to help meet our country's many water supply challenges.

BUSINESS DRIVERS AND INITIAL CONCERNS ABOUT IMPACTS OF CLIMATE CHANGE

American Water relies on the environment for its product—the provision of safe and affordable water to its customers. The utility's ability to draw, treat, and provide water to customers is directly affected by the variation and intensity of rainfall and can be impacted by both flooding and drought. Changes to historical patterns of water availability and quality affect how much water the company can expect to access and whether they can meet expected demand, where plants are located, and the water treatment technologies used.

Water Availability and Quality

According to the U.S. Environmental Protection Agency (EPA), over the last five years nearly every region in the United States has experienced water shortage and as many as 36 states anticipate shortages by 2013, even in the absence of drought conditions.[1] Drought may leave customers dry and could stoke competition among stakeholders for water resources. With water treatment plants located very close to water sources, having too much water can be just as problematic for operations as having too little. Storms and floods may overwhelm systems and interrupt operations. The quality of the available water supply can also be affected by salt-water intrusion into groundwater. Salinity levels that exceed U.S. drinking water standards could require the development of new water sources (surface water treatment) or the installation of advanced water treatment technologies (such as brackish water desalination), which are both more energy-intensive (**Box 1**).

Infrastructure and Energy

The company's infrastructure can be vulnerable to stresses and disruptions from changes in weather patterns, higher temperatures, more frequent and severe storms, longer and more frequent droughts, and rises in sea level, all of which are exacerbated by climate change. Severe droughts in the Midwest in 2010 caused the ground to shrink and crack, leading to an increased number of water main breaks nationally, including in American Water systems. American Water operates or has operated facilities in hurricane-prone regions, including a customer call center in Pensacola, Florida, and a wastewater plant in Jefferson Parish, Louisiana, that was affected by flooding from Hurricane Katrina in 2005. Storms and hurricanes may not only inundate facilities, they can also interrupt the electricity needed to operate treatment plants and the communication systems needed to quickly restore service. After hurricanes Floyd and Irene in 1999 and 2011, widespread power outages and floods in the Northeast disrupted service in the company's New Jersey and Pennsylvania systems. In 2012, Hurricane Sandy knocked out power and communication systems for an extended time period (up to 15 days in some locations) and over a widespread area from New Jersey to Connecticut, causing water and wastewater utilities to rely entirely on emergency power generation to provide service.

Like all large users dependent on electricity from the grid, water utilities must plan for power outages and develop plans for maintaining continuity of operations when such outages occur. The severe impacts, however, from extreme weather events in recent years have prompted American Water to create more redundancies in its fuel supply and communications equipment than ever before. The storm surge, wind, and wave energy from "Superstorm" Sandy also resulted in significant destruction of property and underground infrastructure for a large coastal region. Underground infrastructure is generally felt to be less vulnerable during extreme weather events, but the effects of Sandy has changed that thinking, at least among the affected utilities.

A Context of Multiple Stresses

These climatic changes amplify the effects of stresses caused by urbanization and population growth. The proliferation of impervious surfaces—parking lots, roads, and roofs—associated with urbanization intensifies the impact of climate changes. Flooding, for example, is accelerated by faster rain collection and run-off into streams than has been experienced in the past. Suburban growth over the past 50 years has also increased the presence of mature shade trees around above-ground power and communications lines critical to water industry operations. The requirements of local shade tree commissions often inhibit power utilities from removing or trimming these trees, thus amplifying the impact of severe storms and making recovery more challenging. While newer communities have installed these utilities underground, the significant cost to move these utilities underground in older communities remains prohibitive.

Box 1: Trade-offs Between Saving Water and Saving Energy

The water utility industry is a contributor to climate change, through its high consumption of electricity, as well as a voice for planning and building resilience since it experiences climate and weather variability first-hand. Water and wastewater utilities contribute substantially to greenhouse gas (GHG) emissions, largely through the electricity used to treat and pump water. A water utility's energy needs can account for as much as 30 percent of its operating budget.[2] The industry overall uses an average 4 percent of U.S. electricity and 7 percent of global electricity. In some regions such as California, the water industry uses nearly 20 percent of the total electricity consumed. Nearly 93 percent of American Water's GHG emissions come from electricity use, used largely for pumping water,[3] from a combination of natural gas use (for buildings and treatment facilities) and gasoline and diesel fuel use (for vehicles and generators).[4] American Water plans to reduce GHG emissions 16 percent per volume of water produced by 2017 from 2007 levels through efforts to improve the energy efficiency of its water pumps and help customers conserve water. Yet despite these efforts, the industry's efforts to respond to the physical effects of climate change can mean using more energy-intensive processes in other areas. For example, poor source water quality or increased salt water intrusion from sea-level rise will require technologies that are more energy-intensive to operate, such as desalination or advanced oxidation water treatment processes.

American Water expects continued population growth in the U.S. West and Southwest to exacerbate the regions' limited groundwater and surface water supplies. The water-stressed Southeast is also rapidly increasing in population, and, especially in coastal areas, is increasingly vulnerable to storms and salt-water intrusion into groundwater. American Water is examining the implications of increased flooding and drought for the long-term resilience of its water and wastewater systems.

Business Drivers

Water variability and climate change have the potential to expose American Water to operational interruptions and property damage, with implications for the company's ability to meet the needs of its customers. As a result, the company works to mitigate these risks in a variety of ways including (i) conducting detailed engineering planning studies that analyze potential water risks, (ii) enhancing operational and energy resilience and efficiency, (iii) incorporating more water re-use and wastewater treatment capacity, and (iv) exploring new technologies, even from outside the industry, that would expand water availability in innovative ways.

American Water's actions to manage climate-related risks today also helps the company stay ahead of possible future regulatory risks, such as more stringent standards for water efficiency or increased regulation of nitrous oxide (N_2O) emissions from water treatment.[5] But American Water is taking action to address climate and water risks largely without a U.S. government mandate on managing changes to climate and water resources. American Water's efforts are driven by what it sees as significant opportunities to become a more resilient utility service provider and a more efficient business, to manage critical short- and long-term risks to the company, to reduce costs, and to provide greater value to its customers. Moreover, the company believes its active role in developing new technologies will position it to potentially capture new markets as the value of water efficiency and conservation continues to grow.

COMPANY RESPONSES

Managing water and climate risks is not new to American Water: according to the company, "the climate has always been changing." But the company is experiencing greater climate variability now than in the past. The company believes its expertise in managing past variability prepares it to manage expected future change, particularly as climate change impacts are expected to play out gradually and over a long period of time. To American Water, managing *water risk* is largely considered "business as usual;" managing *physical climate change risk* means incorporating projections about future water availability and impacts on infrastructure, under anticipated but uncertain changes in climatic conditions.

Risk Assessment: Planning Studies for Engineering and Operations

A systematic approach to assessing vulnerability of water supply to climate variability is embedded into American Water's engineering planning studies and operational business continuity planning. The engineering and operations team examines every facility and its regional water availability to develop a capital plan—how much investment is needed, based on a five-year planning cycle, to meet future infrastructure needs—as well as create a 20-year outlook that incorporates estimates of population growth, urbanization rates, and other factors. Business continuity and emergency response plans are also developed or updated to increase the company's preparedness for addressing climate-related scenarios.

Climate change factors may not be explicitly included in a capital plan if there is not sufficient detail for physical climate change impacts in particular geographic zones and within the 20-year planning horizon. The company will, however, conduct a sensitivity analysis of its historical record of water variability with future predictions and "safety factors"—an analysis that can consider accelerated impacts such as a 100-year flood occurring every 20 years or a 20-year flood occurring every five years (**Box 2**), or extremes such as the historic 300-year flood along the Mississippi River that occurred in 2008. The water supply safety factors are a judgment call that balance project costs with operational reliability and dependability. The company's 20-year planning horizon allows for incremental, "no regrets" improvements using the most up-to-date available data over the 50 to 80 year lifetime of an asset. The engineering planning studies drive American Water's capital needs assessments, business planning, and financial forecasting.

The engineering planning studies have the added benefit of providing the company with a strong foundation for communicating with state utility regulators and local government officials about the impacts of climate change, the integrity of water supplies and infrastructure, and the need for a more integrated approach to

Box 2: Variables and Resources

American Water's planning studies take into account:

- Historical water variability records
- Regional urbanization trends
- Expectations about population growth
- Local and regional per-capita use of water
- Regional availability of water supply
- Current and future regulations impacting the quantity and quality of water supplies

American Water's in-house engineering team relies on extensive historical records of its water systems' supply withdrawals and customer water usage patterns, as well as government databases (such as those from the U.S. Geological Survey) that track the quality and quantity of groundwater and surface water supplies. To a more limited extent, the team has also relied on university studies on water use and conservation that indicate a 1 percent decline in U.S. per-capita water use per year across the past 10 years—a trend that the company expects will continue.[6] The U.S. EPA's Climate Ready Water Utilities Working Group[7] was also a very helpful forum for sharing lessons among utilities.

water resource management (described below). The studies have proved to be a valuable tool for making the business case to state regulators, who assess costs and rates based on historical records, for investments in systems that will operate in a climate diverging from historical trends.

Decisions Consider a Number of Factors

American Water emphasizes, however, that the conclusions from its risk assessment models and planning studies do not necessarily translate into a decision to invest in infrastructure upgrades or new technologies, or to otherwise build resilience into the system. Given persistent uncertainty about the precise nature and timing of climate change impacts, it can be difficult to justify investing large amounts of capital solely to safeguard systems against extreme weather- or climate-related events beyond standard engineering criteria, or to take steps that add significant safety margins to the system's risk profile. Thus, consideration is also given to other factors in determining the need for upgrades, such as equipment age, condition, and historical performance; opportunities to improve efficiency through better technologies; and ability to meet future regulations and growth projections. Typically it is a combination of these business drivers that triggers infrastructure upgrades, and climate change impacts can be an added consideration such that investments are made as a "no regrets" approach.

As part of its business continuity and investment planning, the company has made a number of decisions over the years to modify operations, harden systems, and even relocate plants. Between 2007 and 2010 American Water invested $800 million to $1 billion annually in system improvements.[8] In a few cases, investment decisions were augmented by concerns caused by extreme weather.

- After the Mississippi River flood in 1993, American Water decided to move its Alton, Illinois, plant to higher ground. Given the plant's age, the limited opportunity for future expansion, and the company's expectations about climate change and increased flooding, the plant was decommissioned and a new one built at a higher elevation.
- After Hurricane Floyd in 1999, the company installed a floodwall at a major plant in New Jersey. Twelve years later, that investment decision proved to be invaluable when flooding from Hurricane Irene came within an inch of the top of the floodwall, which protected a critical water supply facility serving a large population. The company recently received approval in Iowa to increase floodwall protections—a 2,000-foot earth levee around three sides of the plant—at its Davenport facility along the Mississippi River.
- Engineering guidelines for new buildings in flood zones require that facilities be built high enough that system electronics are protected from potential floodwater.
- In the drought-prone U.S. Midwest, the company has replaced turf grass with natural prairie grass at a number of locations that, in addition to

supporting local wildlife, needs much less water to maintain.

- To help resolve ongoing severe water scarcity in Kentucky, which may further intensify with climate change, the company constructed a $164-million water treatment plant to help ensure adequate water supply to the growing region.
- The company is working toward replacing older, inefficient pumps in water treatment plants through 2017. This effort is timed seasonally in order for the company to maintain customer service as well as meet operational requirements for pumps available for back-up needs. This phase-out will both reduce energy use and help minimize risk of disruptions in electricity supply.

Risk Management: Managing Long- and Short-Term Imperatives

Managing Long-term Imperatives: Integrated Resource Management

With expectations of a changing climate, part of American Water's management strategy requires making projections about future water availability under uncertain and changing climatic conditions. The company expects changes in climate and rainfall to exacerbate the effects of existing restrictions on the total available water supply in a region, such as government mandates to maintain minimum stream flows. Anticipating these challenges, American Water is adopting a more integrated management approach to water resources that will expand available water supply options through additional water conservation, water re-use, and wastewater treatment capabilities—an approach that has been implemented by the company only on a sporadic basis in the past. American Water's integrated water resource management plans look more holistically at the water cycle to consider:

- The availability and use of alternative or distributed water supplies, for example, water re-use, groundwater recharge, storm water retention and treatment, and non-potable supplies; and technologies that enhance these opportunities
- Integrated analyses of engineering, economic, societal, and environmental costs
- Optimal ways of identifying and managing risk and uncertainty, including emerging guidance on the potential impacts of climate change
- Coordination of planning between water and wastewater utilities, environmental agencies or nongovernmental organizations, land use planners, transportation planning, and others in specific regions[9]

Support from state and federal regulators[10] is critical for the company to achieve these objectives for water risk management. For many state regulators, especially in water-stressed states such as Texas, California, and Arizona, water conservation is a way of life. Regulators in California, for example, have implemented water "conservation pricing" that decouples the price of water from the amount of water that customers use. Regulators in Pennsylvania, New Jersey, Indiana, and Illinois are beginning to explore the costs and benefits of water conservation tariffs. For American Water, these policies help achieve its water risk management objectives and help the company communicate with customers about the interaction between conservation measures and water prices (**Box 3**).

Box 3: EMC Water Conservation Services

American Water brings its water conservation solutions and know-how to some of its largest customers. The company's Environmental Management Corporation (EMC) provides technologies and operates water and wastewater systems on a contract basis, for example, to help industrial customers to treat and re-use wastewater for industrial processes. For most industries, water is one of the lowest-cost inputs, providing little incentive for customers to invest in conservation measures. Yet when the total cost of water lifecycle management is considered for water service, handling of wastewater, and environmental mitigation measures, to invest in water conservation systems and practices can make economic sense. EMC's customers also find that water conservation has important co-benefits, for example, it enhances their reputation with customers and contributes to their overall corporate sustainability efforts.

Managing Short-term Imperatives: Rapid Response to Extreme Weather

It is just as important to update response planning and procedures to keep up with the increase in extreme weather as it is to prepare for long-term changes in climate. Within the space of a few years, the mid-Atlantic states experienced multiple significant weather events: a December 2010 snowstorm that shut down New York City and coastal New Jersey for five days; Hurricane Irene in 2011; Tropical Storm Lee, an October 2011 blizzard in the Northeast; a June 2012 derecho bringing devastation and power outages from Indiana to New Jersey, Maryland, Virginia, and D.C.; and "Superstorm" Sandy in October 2012. American Water's experience of these events created a renewed focus on business continuity planning and emergency response.

American Water learned that its typical planning standards for back-up power and other redundancies are no longer sufficient. Its typical planning standard for standby power—50 percent of an average day's demand—is no longer adequate for maintaining service for extended time periods after an extreme weather event. The company will be systematically adding additional standby power capacity, in addition to using a more diverse and reliable mix of fuels in its emergency fuel supply. In 2012, New Jersey American Water, which provides service to approximately 30 percent of the state's population, experienced widespread power interruptions from Hurricane Sandy in every service territory. Through the use of both stationary and portable emergency power generation, it was able to provide service to all of its customers. Close coordination with government officials and power utilities helped to restore power at the most critical facilities within five days; for other locations it took up to two weeks. The company also learned from the devastation caused by Hurricane Sandy that it needs to build redundancies into its telecommunications systems—something it has never before had to do. And, the company has started to use geographic information system (GIS) maps and global positioning system (GPS) technologies in some areas to better position valves and meter boxes out of harm's way.

Quickly restoring service also requires personnel with the right skills. After the 1993 Mississippi River flood, American Water was able to bring in personnel from around the country to dry pumps, airlift them to the manufacturer to be rapidly retrofitted, and then re-install them. American Water's plant was running again in five days, while a neighboring plant was not operational for 30 days. More recently, American Water has implemented an emergency response process in accordance with the U.S. Department of Homeland Security's National Incident Management System (NIMS) framework. This comprehensive process facilitates better coordination with federal, state and local emergency management agencies.

Another lesson from these events is the opportunity to deploy non-operational personnel during storms: staff in non-operational roles are pre-assigned specific duties during emergencies to augment the operational staff. For example, in the case of an extreme weather event, engineering personnel will augment the operations staff or be assigned as liaisons to a local emergency operations center. Other functional personnel will be assigned to supplement communications staff during emergencies to ensure critical, timely communication with government officials, other utilities, regulatory agencies, the media and customers.

Business Opportunities: Technology Innovation

Very few water and wastewater utilities have a formal research and development (R&D) program. But American Water considers developing new technologies to be as important as improved decision-making for making the water industry more effective, efficient, and resilient. The company's Innovation Development Program, led by Dr. LeChevallier, is exploring technologies that enhance water and energy efficiency, promote water conservation, and expand the water supply in innovative ways. The program's mission is to identify, develop, and help deploy technologies that will enhance the company's own efficiency as well as open up business growth opportunities to help customers do the same.

The company considers that two of the most important technological solutions for expanding water availability under uncertain conditions are water reuse and desalination. American Water currently operates recycled water systems that process and reuse wastewater for flush water; heating, ventilation, and air conditioning (HVAC) systems; and landscape irrigation—greatly reducing demand for freshwater resources. The company's zero-discharge water recycling plant, developed through a public-private partnership with the city of Fillmore, California, provides 1 million gallons of treated water per day for irrigation and groundwater recharge. In Tampa Bay, Florida, American Water operates the

United States' largest desalinization plant, providing 25 million gallons of water per day through a reverse osmosis process.

Another active R&D area for the company is an energy-efficient wastewater treatment technology called NPXpress. Most of the energy used for treating wastewater occurs during aeration, to remove nitrogen and phosphorous. NPXpress uses 50 percent less oxygen for aeration (and therefore less energy) and fewer chemicals for treatment. The technology enhances energy and operational efficiency and reduces costs, making water re-use a more economical and promising way to expand overall water supplies. The technology is also more effective at reducing nitrogen and phosphorous emissions from plants, which are coming under more stringent government regulation, as well as emissions of nitrous oxide (N_2O)—a very powerful greenhouse gas.[11] American Water is piloting the technology at eight water systems in its service territory, and expects that regulations on N_2O emissions from wastewater plants will become an increasingly important business risk within the next five to 10 years.

American Water is also exploring new technologies and applications from outside the industry to enhance the efficiency and flexibility of the electricity systems that water treatment plant operations heavily rely on. One such example is its partnership with Canadian firm ENBALA, an energy technology developer that had never before worked with water utilities in the United States. The ENBALA Power Network is the first smart grid[12] partnership between water and electric utilities in the United States and, according to Dr. LeChevallier, "marries the flexibility of water systems with the inflexibility of electric systems." Water storage tanks are the key to the flexible marriage: the network allows American Water to provide electricity back onto the electric grid at times when the company is not using energy-intensive pumps but rather is using stored water for service delivery.

American Water initiated the relationship with ENBALA to pilot, validate, and build a business model for the smart grid system. The partnership is currently rolling the system out and expects to have four major systems in place by the end of 2013. Pilot projects are taking place on the PJM power grid, where American Water has a large concentration of customers, and the company has also reached out to grid system operators in California and Illinois.

CHALLENGES AND BARRIERS

One of the major challenges facing the water and wastewater industry in the United States is the age of its infrastructure. Much of the vast network of aging treatment plants, pumping stations, storage facilities, and nearly 700,000 miles of main and collection pipe is in need of replacement or repair. The U.S. EPA estimates that $633 billion is needed for capital improvements to drinking water and sewage infrastructure over the next two decades just to maintain current levels of service.[13] In addition, by some estimates it will cost utilities between $448 billion and $944 billion to address climate change issues through 2050.[14] As American Water describes, "Most of the existing infrastructure in the United States that is designed to ensure U.S. water quality is based upon historical trends of the timing, temperature, quantity of precipitation and water flow. Climate change, however, will likely affect one or more of these variables in almost every area of the country."[15]

The company believes that, with the right enabling policies, there are significant opportunities can be captured over the next 50 years that would improve the efficiency and resilience of U.S. water and wastewater infrastructure. The company has already seen a 10 percent reduction in water use over the past 10 years, largely attributable to U.S. Department of Energy laws that require installation of low-flow toilets and fixtures. A recent survey of consumer attitudes revealed that two-thirds of Americans favor water reuse for activities that can use non-potable water as a sensible way to conserve water resources.[16] Yet regulations about water reuse—if they exist—vary from state to state and have not yet been established at the national level. With few U.S. households and commercial properties yet using such technologies, conservation methods and enabling policies could make a significant contribution to water conservation for decades to come.

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CASE STUDY: BAYER AG

CASE STUDY	BAYER AG
Headquarters:	Leverkusen, Germany
Industry:	Chemicals
Revenues (2012):	$39 billion
Employees:	112,000
Key Initiatives:	• Developed climate change risk matrix to inform operational and R&D decisions • Building awareness and expertise among business units and staff • Engaging in research partnerships analyzing climate changes

COMPANY PROFILE

Bayer AG is a global enterprise with core competencies in the fields of health care, agriculture, and high-tech materials. Bayer HealthCare, with annual sales of approximately $23 billion in 2011, is one of the world's leading companies in the healthcare and medical products industry. The company combines the global activities of Bayer's Animal Health, Consumer Care, Medical Care, and Pharmaceuticals divisions. Bayer MaterialScience is among the world's largest polymer companies, with business activities focused on the manufacture of high-tech polymer materials and the development of innovative solutions for products used in automotive, electrical and electronics, construction, and sports and leisure industries. The group had sales of approximately $14 billion in 2011. Bayer CropScience, a subgroup of Bayer AG responsible for the agricultural business, had annual sales of approximately $9.5 billion in 2011 and is one of the world's leading innovative crop science companies in the areas of seeds, crop protection, and non-agricultural pest control.

BUSINESS DRIVERS AND INITIAL CONCERNS ABOUT IMPACTS OF CLIMATE CHANGE

The effects of climate change—warmer temperatures and increasingly variable weather extremes and precipitation patterns—will have significant effects on Bayer's customers. The company considers these effects to pose more of an opportunity to better serve evolving customer needs than a risk to its bottom line. Based on extensive analysis of risks to its facilities, it has concluded that disruptions to operations, supply chain, or product delivery are already sufficiently minimized through supplier diversification and through strategies that build redundancies and flexibility into operations. But climate change impacts will increase demand for some of its existing products and drive development of new innovations that help Bayer's customers in climate-sensitive sectors—agricultural producers, healthcare providers, and construction companies—to cope with more extreme weather events. For example, the United Nations Environment Program (UNEP) warns that rising temperatures and changing weather patterns could lead

to an increase in malaria infections of 40 to 60 million cases in Africa alone, creating a stronger need for Bayer products that treat and control the disease.[1] As global average temperatures rise there will be more demand for products that help manage temperature and energy use in buildings, such as Bayer's advanced insulation materials, and greater water scarcity is driving demand for more drought-resistant and stress-tolerant seeds.

COMPANY RESPONSES

Risk Assessment: Climate Change "Risk Matrix"

The company considers the most important risk management issue in the chemical industry to be safety. Ensuring the safety of employees, consumers, and the public is paramount to maintaining Bayer's license to operate. The kinds of impacts from extreme weather—power outages interrupting production, water shortages delaying product delivery—are the kinds of risks that the company is already significantly invested in mitigating to ensure the safety and security of operations.

Business risks are collected and analyzed in Bayer's centralized BayRISK management database. Each quarter, data on key performance indicators (KPIs) such as safety incidents, energy consumption, water use, and emissions at business units are submitted to a globally integrated BaySIS site information system. This site-specific information compiled each year enables the identification of year-on-year comparable trends, and supports capital investment decisions including for research and development (R&D). The 18-member staff of Bayer's Environment and Sustainability (E&S) group share information and analyze environmental risks through a community of practice–based system. E&S managers meet quarterly at headquarters to assess risks affecting investment decisions and R&D strategy in the Sustainable Development, Technology and Innovation and the Health, Safety, Environment and Quality Committees. A member of the Board of Management of Bayer AG leads the committees and ultimately makes decisions about whether a shift in practice is necessary.

Starting in 2007, the E&S group began to develop a better picture of climate change risks to its operations and customers. One of the drivers was Bayer's commitment at the World Economic Forum to a public-private partnership promoting more resilient and sustainable agricultural systems. Another driver was the losses and damage experienced from Hurricanes Katrina (2005) and Ike (2008) at the company's operations in Baytown, Texas (**Box 1**). Managers wondered whether changes needed to be made to anticipate similar risks in the future. The first step was to start building awareness internally in a way that connected the issue to the business. The E&S group does not talk about impacts from "climate change," but rather about the increased risks from weather extremes in terms of, for example, changes in yield or impacts on cooling water availability—challenges that the company has already experienced or witnessed over the last decade. Stronger storms, flooding, and drought are readily visible, and managers care most about those near-term impacts on their businesses.

To build internal knowledge and expertise on extreme weather and climate change impacts, Bayer's E&S subgroups are engaging in strategic research projects with publicly funded research organizations. A partnership with the Potsdam Institute for Climate Impact Research developed scenarios of changes in hydrology, air temperature, sea level, and river flows that may affect how agricultural and healthcare sector needs might evolve on different continents over the next 10, 50, and 100 years. Bayer is also a founding member of Climate-KIC, a knowledge-sharing group established by the European Commission that, among other things, works on projecting, forecasting, and managing climate extremes.

These analyses have identified increases in precipitation, weather extremes, and droughts due to climate change as potential risks. Sites in coastal regions (Baytown, Texas; Map Ta Phut, Thailand; Caojing, China; Cuddalore, India) may be exposed to more damaging hurricanes. Several sites in Europe, North America, and Asia are potentially threatened by flooding, and the company's Indian site may be subject to monsoon rains, which could disrupt or halt plant operations or damage property. Longer droughts could lead to indirect impacts on the company, such as higher energy costs or electricity service disruptions. And disruptions or increased costs in the shipping-based parts of Bayer's logistics, on which it relies for critical supplies of salt and coal in Germany, for example, could occur if river water were to fall below critical levels.[2]

Bayer's analysis does not indicate that these risks will have a substantive impact on its operations within the next 10 years. A risk evaluation of company sites by Bayer's insurer Pallas Insurance indicated no change in exposure to weather-related risk; the evaluation estimated the probabilities for "worst-case scenario" events and the need for additional protective measures to be very low.[3] Climate change factors *per se* are therefore not

Box 1: Rebuilding at Baytown

Like all responsible chemical manufacturers, Bayer considers the possible safety risks from natural disasters such as earthquakes, tornadoes, and hurricanes when siting new facilities and planning for the safe shutdown of plants after a disruptive event. The effects of Hurricanes Katrina and Ike—in which the Baytown plant was minimally affected but employee homes and communities suffered significant damage—shifted the focus of Bayer's risk analysis to the importance of employee support and community aid in restoring normal business operations. Bayer responded to Hurricane Katrina by providing communities with tarps, chain saws, flashlights, over 200 generators, ready-to-eat meals, water, first aid supplies, and cleaning supplies. In addition Bayer provided:

- A work crew to visit employees' homes to place the tarps on roofs, since many people have a hard time maneuvering on steep roofs
- Seven tanker trucks, each holding 8,000 gallons of fuel, to fill up employees' cars and generators
- Temporary trailers for employees whose homes were so damaged that they were no longer inhabitable
- Funds for immediate repairs, from Bayer employees at other sites
- Catering services that served hot meals from the company parking lot 24 hours a day for over three weeks

The company learned from this experience that rebuilding affected communities after an extreme weather event is as important as the procedures for safely shutting down and restarting the plants themselves.

explicitly captured in the BayRISK database. That said, trends in extreme weather, drought, or precipitation may be seen through historical changes in KPIs over time that indicate changing water resources or energy use due to rising temperatures in different regions.

To help the company consider the potential future risks from climate change impacts, the E&S group worked with financial experts to build a climate change "risk matrix" with which to evaluate and prioritize climate-related risks over Bayer's 10- to 20-year planning horizon. The risk matrix is used as an overlay to improve the analysis of the BayRISK database information. The 5x5 matrix ranks risks according to their potential extent of damage and frequency of occurrence, and assigns a simple high, medium, or low impact rating. For example, when the potential supply chain risks related to shipping were assessed, lower water levels on the Rhine River due to more intense droughts were assigned a rating of "low risk" in the BayRISK System, given the availability of alternate transport via rail and truck.

These climate change and extreme weather assessments, only five years old, are still in their early stages, but they will likely become more critical for corporate planning in the future. Moreover, given the long lead times required for bringing new innovations to market—from five to 15 years—and planning for investments in assets that last for up to 50 years, information provided to Bayer's scientists and strategic planners today is helping to inform decision-making for the future.

Risk Management: Supplementing Business as Usual

Bayer is already heavily invested in maintaining a flexible global production system in order to ensure safety, provide for continuity of operations, and meet obligations to customers. Globally distributed manufacturing sites and supply chains ensure that Bayer is able to shift supply of products among sites in the event of potential catastrophes, including those caused by extreme weather. Furthermore, the company believes that existing risk prevention practices and emergency response plans could be readily adapted if weather extremes were to increase in the future.[4] Of particular importance for Bayer's business continuity planning is ensuring reliable and high-quality supplies of energy and water. If power supplies or cooling water is lost, it can sometimes take up to a full—and costly—week to restart a Bayer production plant.

The climate change "risk matrix" is helping Bayer to think about future impacts on power supply or cooling systems from extreme weather events or changes in water availability. To mitigate production losses and safety issues from electricity outages, Bayer is both reducing sites' energy consumption and seeking alternative forms of energy and energy storage solutions that would increase flexibility of energy supply in the future.

Extreme weather and climate change factors are also making their way into decision-making about major new investments. Bayer's new manufacturing site in coastal Caojing, China, is located in a low-lying geography very similar to that of Baytown, Texas. Bayer's safety program applied the lessons learned from plant shutdowns after hurricanes near Baytown to enhance its Top Performance in Process and Plant Safety Program (TOPPS) employee safety training and materials at the new Caojing site. It also has developed more extensive plans to provide relief directly to company employees following any weather disasters.

Business Opportunities: Climate-Smart Solutions

For Bayer, one of the most important uses of information about past and future changes in climate, precipitation, and extreme weather is understanding how its customers' needs will evolve. Many of Bayer's product development and R&D efforts have focused for decades on the business challenges that customers face with volatile and unpredictable weather. Bayer customers are not necessarily asking for "climate change" protection *per se*. Yet the company is increasingly seeing impacts to its customer segments from extreme weather and is learning about future impacts from its research partnerships and climate "risk matrix," which validate its continued focus on innovative solutions for a more drought-ridden and unpredictable climate. The company's decision to extend an R&D partnership[5] that is developing advanced mosquito nets to control malaria came out of its initial evaluation in 2007 that indicated warmer temperatures, higher precipitation and more mosquitoes in some parts of the world in the coming decades.

> ***"Being forward-thinking affords market advantages. Providing information to our scientists and strategic planners now about climate changes occurring over the 10, 20 or even 50 years is helping to inform decisions today about innovation and competitiveness for the future."***
>
> *—Achim Ilzhoefer, Corporate Environment & Sustainability Center, Bayer AG*

Warmer temperatures and more damaging weather events have implications in particular for Bayer MaterialScience (BMS) and Bayer CropScience (BCS) business units. BMS estimates that approximately 20 percent of its approximately $9.7 billion in 2011 revenues came from climate-related business and BCS's business as a whole is climate-related since it serves the agricultural sector. BCS is already seeing how water shortages, heat, and excessive rainfall are affecting agricultural yields for crops such as maize, barley, and wheat: these stresses are reducing yields in some cases up to 80 percent.[6] Rising temperatures and more severe storms will require both better insulation to save energy and stronger building materials developed by BMS.

Bayer has been pursuing these opportunities by investing in new products, expanding its R&D capabilities for existing product lines, and forming research partnerships:

- Emerging "climate-smart" agriculture combines practices and technologies that increase crop productivity and resilience to weather stresses, along with reduced environmental impact.[7] Bayer recognizes that trends in climate change impacts, combined with predicted world population growth over the next several decades, will likely drive higher food prices and thus drive business growth for the company. BCS is investing in R&D for products that alleviate the consequences of changing weather patterns—including floods, droughts, heat, cold, and storms—on crop yields. For example, the insecticide Confidor improves the resilience of crops against potentially greater incidence of pest outbreaks as well as against increased groundwater salinity. BCS is investing approximately $26 million over the next five years to expand its seed research laboratory in Singapore to support the development of pest- and heavy weather-resistant seed varieties and hybrids. BCS is working with Australia's national science agency to develop cereals better capable of growing under moisture and heat stress. In 2011, BCS estimates that it spent approximately $37 million on R&D related to climate change.[8]
- Because buildings have a typical lifespan of 80 or more years, their existing equipment and systems—including HVAC, lighting, windows, and control systems—is often outdated and inefficient. Annual revenues from the buildings retrofit business in the United States are estimated to be $16 billion by 2020.[9] Demand for building materials may also increase as destroyed buildings need to be rebuilt. BMS' high-performance polycarbonate

insulation materials lend enhanced stability to buildings exposed to severe storms, in addition to increasing energy efficiency.[10] In the United States, BMS formed the Impact Shielding Team in 2011 to develop and commercialize building protection solutions for structures in high-risk environments. In 2011, BMS estimates it spent approximately $120 million on R&D related to climate change.[11]

- In light of the expected spread of malaria, BCS worked in partnership with the World Health Organization to bring LifeNet mosquito nets to market in May 2012, that continuously release insecticidal protection against mosquitos.

Bayer expects that the most significant impacts to its customers from climate and weather changes are still 10 years away but that they will drive demand and business growth for products already on the market and for new innovations. Given the long lead times required for commercializing new innovations—it can take 15 years to bring a new genetically modified crop variety to market—information gathered today will help inform decision-making for years to come.

CHALLENGES AND BARRIERS

Bayer recognizes that relying on the BayRISK database of past trends and risks is not sufficient for predicting future extreme weather events, especially when they will be made more volatile and unpredictable with climate change. Bayer's climate change research partnerships and its "risk matrix" developed over the past five years are helping to add a forward-looking picture of risks beyond what the BayRISK analysis provides. The E&S group receives solid support from management for its risk assessments, given Bayer's already strong commitment to investing in capacity and knowledge building that will drive risks down and build operational flexibility at every company site.

But the climate change risk management program is still in its early stages, and the E&S group still finds it challenging to convince decision-makers and board members of the need to act on the wider picture of risks that forward-looking scenarios of climate and weather changes suggest. Part of that challenge is difficulty with communicating about climate- and weather-related risks whose timing and locations are inherently unpredictable. Climate change not only imposes physical constraints on Bayer and its customers but also multiplies the level of unpredictability around availability, quality, and price of key commodities such as energy and water. The nature and magnitude of risks change at each Bayer site in each country every year, and it is difficult to develop a long-term picture of future risks that will be applicable to each site, business type, and regional location. And forward-looking scenarios of future change, while helpful, are still only limited tools generating predictions—not proof—of more frequent or severe impacts.

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CASE STUDY: THE HARTFORD

CASE STUDY	THE HARTFORD
Headquarters:	Hartford, Connecticut
Industry:	Property & Casualty Insurance
Revenues (2012):	$26.4 billion
Employees:	20,000
Key Initiatives:	• Expanded data collection and primary research • Careful market expansion • Building awareness of challenges among regulators, customers, and stakeholders

COMPANY PROFILE

With more than 200 years of expertise, The Hartford (NYSE: HIG) is a leader in property and casualty insurance, group benefits, and mutual funds. The company is widely recognized for its service excellence, sustainability practices, trust, and integrity. Founded in 1810, The Hartford is headquartered in Hartford, Connecticut. More information on the company and its financial performance is available at www.thehartford.com.

BUSINESS DRIVERS AND INITIAL CONCERNS ABOUT IMPACTS OF CLIMATE CHANGE

Insurers and reinsurers are some of the first companies to recognize emerging trends and risks, and many have been at the forefront of developing and improving models that examine changes in weather and climate risks. Losses from extreme weather events have been impacting insurers for years and are increasingly challenging their risk models and underwriting capabilities. Since the 1980s, average annual U.S. winter storm losses have nearly doubled,[1] and losses from drought during 2012—estimated to be at least $12 billion—could be the highest since 1988.[2] In 2011, extreme weather events cost U.S. property and casualty insurers more than $32 billion.[3] Droughts alone are expected to cost insurers roughly $20 billion in 2012, most of which is borne by the federal crop insurance program and more than $5 billion paid by private insurers.[4] Losses from "Superstorm" Sandy that caused considerable damage to the U.S. Northeast in 2012 totaled $65 billion.[5] The Hartford's initial estimate for its catastrophe losses in 2012 from Sandy alone is approximately $370 million.[6]

Risk models incorporating current and future climate variability and continued growth in economic activity in coastal and flood-prone areas indicate that underwriting costs will continue to rise as damages from extreme weather occur and claims increase for property, housing, and life insurance. Rising weather-related catastrophic losses, potentially magnified by the effects of climate change, present a very real and significant challenge to the sector's financial performance, particularly amid an overall sluggish economy. The insurance sector also plays a critical role in enabling better decision-making about the risks associated with, for example, building homes or siting facilities areas that are likely to see more climate impacts over the life of the asset.

COMPANY RESPONSES

Risk Assessment: Enterprise Risk Management

Property and casualty insurer The Hartford has assessed the impact of weather risks from hurricanes, fires, tornadoes, snowstorms, floods, and other events on its individual and commercial policyholders for decades. It began taking a closer look at the effects of climate change as a material risk in the mid-2000s, based on climate change projections of the Intergovernmental Panel on Climate Change (IPCC) and associated scientific research.[7] To evaluate climate risks, The Hartford's independent Enterprise Risk Management (ERM) group examines peer-reviewed scientific literature from universities and government sponsors to understand temperature changes, extreme weather, and the dynamics of climate change, and translates that information into the business context for the company's insurance products and implications for policyholders. The ERM group also uses third-party risk assessment models, which forecast the probability of weather and catastrophe events, to analyze the uncertainties associated with the nature and timing of climate variability and extreme weather. These models have limitations, however: they often provide only a high-level picture of climate variability in the short- to medium-term, on decadal scales, or at regional levels that are not readily applied at a state or local level, and they often rely on historical records that may not accurately capture future change. The Hartford's ERM team, therefore, supplements these tools with the latest research on climate variability and the potential for climate change.

While it is difficult to know with certainty the role that long term climate change will play in altering weather patterns, the results of the ERM's analysis track with changes that The Hartford is already seeing in the United States—warmer temperatures, more extreme high and low pressure systems, and more intense storms. In 2011, The Hartford paid out $745 million in natural catastrophe claims, more than the combined average catastrophe losses over the previous 10 years.[8] Although the company emphasizes that it is impossible to ascribe any single weather event to anthropogenic climate change, it has adopted a new view of climate and weather risk that incorporates the adverse effects of increasing climate variability observed over the past five to 10 years.

Risk Management: Reflecting Risks in Pricing and Policies

The company's analysis has influenced its actions over the past couple of years and, moving forward, how it thinks about its products for homeowners in different parts of the country. First and foremost, from an underwriting perspective, climate risk analysis is critical for ensuring that customers are appropriately covered for risks and that insurance policy prices accurately reflect those risks and costs. Appropriately priced insurance products can encourage customers to take steps to mitigate risk or to adopt new behaviors to control risk exposure.

Yet it remains extremely difficult for insurers to evaluate and incorporate the full costs of climate change into product pricing. The granular level data and tools to support decision-making about an accurate and reasonable price is not yet available, and climate modeling tools are still limited in their scale and applicability. Moreover, without detailed, empirical data and possible ranges of local climate and weather impacts, it remains difficult for the insurance industry to effectively communicate a compelling case to state regulators about appropriate levels of insurance coverage and the need to incorporate full pricing of climate change factors into insurance products. As a result, the mitigation incentives that pricing signals can provide to customers and society are also limited.

The Hartford's climate risk management activities therefore involve several additional strategies:

- **Climate risk and reinsurance.** Part of The Hartford's strategy for minimizing the impacts of extreme weather involves sharing climate risk by purchasing reinsurance policies from international reinsurance companies that have a larger scale and a greater ability to diversify risk across the globe. Reinsurers' analysis of the actual costs and risks of climate change and extreme weather determines their own product pricing, so it is important that their views and analysis be aligned with The Hartford's. Consequently, the company works closely with reinsurers to understand their perspectives. Information gleaned from global reinsurers about climate change has also helped inform The Hartford's own decision-making about managing risk.

- **Careful expansion.** Given the very long-term commitment that it makes when entering new markets, The Hartford also considers climate changes and risks when evaluating concentrations within its own portfolio of policyholders. Understanding the long-term changes in storm activity, sea-level rise, or flooding in a particular region is an important step to ensuring that rates and loss exposure are manageable—ensuring that The Hartford is well positioned to meet policyholder claims when claims do arise. As a result, The Hartford has managed its overall insurance portfolio to limit unwanted concentrations of risk at a regional, state, and even zip-code level and has reduced coastal exposures significantly over the past five years.
- **Engagement with regulators and customers.** The Hartford's efforts to more accurately price the climate risks embedded in its insurance products can only go so far to influence policyholders' behavior. For example, even where the company is able to revise its prices to reflect increased risks from more severe hurricanes, if building and development continues at its rapid pace along U.S. coasts without accounting for the increased risk, there will still be damages and economic losses suffered, and even farther inland than previously experienced. The Hartford, along with its industry peers, has therefore been a strong advocate at both the state and federal levels for public policies that:
  1. Ensure that insurance rates reflect the real costs of weather risks, in order to guide individual decision-making and encourage policyholders to undertake appropriate levels of risk mitigation
  2. Reduce overall societal exposure to climate change through improved land-use planning and public-sector mitigation efforts, especially along the coasts
  3. Encourage self-sufficient insurance mechanisms within the states to reduce public subsidies that have the potential to exacerbate the growth in exposures at risk from climate change

The Hartford is also working on improved underwriting guidelines that would provide incentives to homeowners to make better decisions about roofing material and installation in areas at risk of more severe storms.

CHALLENGES AND BARRIERS

The insurance industry as a whole faces several challenges—and opportunities—for evaluating climate risks and incorporating them into decision-making.[9] More detailed, granular data and information are needed to better understand the risks and incorporate them into policies and product pricing. More government- and university-sponsored research that provides empirical, objective, science-based information would help decision-makers to determine, as The Hartford describes, "the pricing, the right incentives, and the right approach with product delivery to help customers" better manage climate and extreme weather risks.

Insurers can also be working directly with climate scientists to translate their research findings into a business context and to develop improved modeling capabilities that factor in the likely effects of climate change on extreme weather. Insurers can lend their expertise to inform land-use planning, infrastructure design, and building codes to help build on-the-ground capacity in critical population areas. These improved capabilities can support insurers' engagement with state regulators and customers about the nature of climate risks, how the risks impact rates, and the steps that need to be taken to increase the resilience of homes and businesses in a future of increasing, and increasingly unpredictable, weather.

ENDNOTES

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CASE STUDY: NATIONAL GRID PLC

CASE STUDY	NATIONAL GRID PLC
Headquarters:	London, United Kingdom; U.S. Headquarters: Waltham, Massachusetts
Industry:	Electric and Gas Utilities
Revenues (2012):	$22.5 billion
Employees:	27,000
Key Initiatives:	• Evaluated business resiliency against a "worst case" scenario of climate changes through 2080 in UK • Assessing flood risks in key U.S. geographies • Prioritizing investments to reduce interruption losses

COMPANY PROFILE

National Grid is an electricity and gas company that connects consumers to energy sources through its networks. The company is at the heart of one of the greatest challenges facing our society—to create new, sustainable energy solutions for the future and developing an energy system that underpins economic prosperity in the 21st century. National Grid holds a vital position at the center of the energy system and we 'join everything up'. In Britain, National Grid runs the gas and electricity systems that our society is built on, delivering gas and electricity across the country. In the North Eastern U.S., National Grid connects more than seven million gas and electricity customers to vital energy sources essential for our modern lifestyles.

BUSINESS DRIVERS AND INITIAL CONCERNS ABOUT IMPACTS OF CLIMATE CHANGE

Current and anticipated impacts from climate change—warmer temperatures, stronger storms, heavier precipitation, and sea-level rise—pose significant challenges for maintaining reliable, safe, and affordable electricity and natural gas service. In October 2012, "Superstorm" Sandy caused an estimated $65 billion in damage to the New York City metropolitan area and surrounding region.

Before this storm, unusual weather in 2010 had already raised awareness at National Grid, with an unprecedented number and variety of events from extreme flooding, significant snowstorms, and hurricanes:

- Flooding in Rhode Island in 2010 that impacted both the gas and electricity systems
- Widespread power outages in New York, Massachusetts, Rhode Island, and New Hampshire from damaging winds, torrential rains, and flooding caused by Hurricane Irene in August 2011
- Historic flooding in September 2011 across New York from Tropical Storm Lee
- A rare "white Halloween" in October 2011 with unexpected snowstorms that damaged power lines, followed by very little snow in the region for the rest of the winter

From Hurricane Irene alone, 1.4 million National Grid customers lost power, drawing the ire of Massachusetts regulators and leading to an $18.7 million fine.[1] The UK has also experienced an increased number of overwhelming and costly floods in the last decade. Major floods overwhelmed National Grid substations in South Midland, South Yorkshire, and Carlisle in 2005 and 2007. Over the coming decade and beyond, National Grid expects that encroaching sea levels could threaten coastal

facilities, particularly in Massachusetts, New York, Rhode Island, and parts of the UK. Hotter days will also continue to create periods of peak demand for electricity[2] in addition to putting heat stress on circuits and equipment.

COMPANY RESPONSES

Risk Assessment: U.S. versus UK Approaches

National Grid's approach to understanding climate risks has been shaped by very different attitudes in the UK and United States about addressing climate change. With approximately half of its business located in the UK and half in the United States, National Grid's climate risk assessment has to be tailored for the impacts, assets, practices, and regulations for each business. In the UK, due largely to the recent public mandate to report on climate change risks,[3] National Grid works directly with the national government to evaluate risks and is taking a leadership role in helping to prepare the energy sector for impacts expected through the end of this century. In the United States, in the absence of any national effort to address resilience, National Grid works in a more decentralized manner, primarily with state task forces on risk assessment and mitigation for specific types of extreme weather events such as hurricanes and floods.

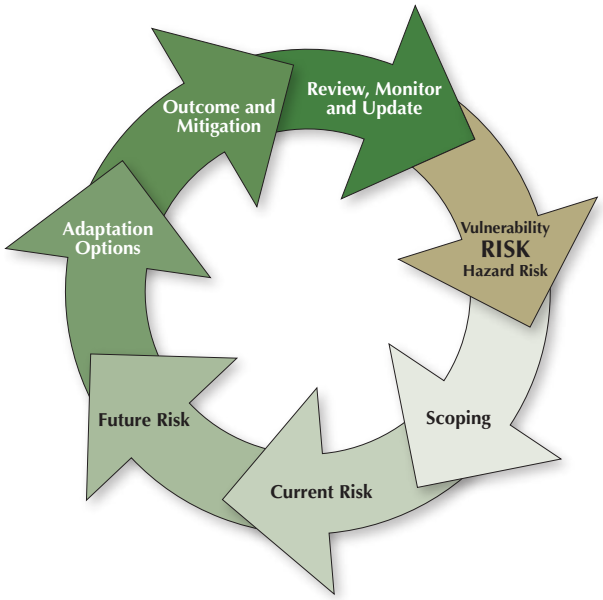
In the UK, National Grid has studied the impacts of a changing climate since 2006 with the support of prominent national groups including the UK Met Office (the national weather service), which acts as a "one-stop shop" of information and assistance on climate and weather, and the UK Climate Impacts Programme (UKCIP) established by the UK government in 1997, which coordinates national research and tools that companies can use to evaluate and manage climate-related impacts.[4] In 2008, National Grid and other UK energy companies commissioned the Met Office to conduct a qualitative assessment of potential impacts. One of the key outcomes was a study that integrated climate change science and modeling tools with a risk-based business planning process over a 15- to 40-year timeframe for energy asset investments.[5] Among the issues investigated were the impact on cables from changes in soil conditions, how urban heat islands might affect power and gas infrastructure, and extreme weather effects on the resilience of electricity networks. The study also produced a tool to predict sea-level surges and models of wind projections. This analysis indicated that industry design standards for infrastructure resilience to heat or flooding were sufficient for some equipment, such as overhead line conductors, but the design standards would be exceeded for some equipment, such as distribution transformers.

In 2010, National Grid served as a pilot partner in an initiative by the UK Department for Environment, Food and Rural Affairs (Defra) to assess climate change risks to gas and electricity systems, and to help prepare companies in critical sectors for mandatory reporting on these risks starting in 2011.[6] National Grid used climate change projections provided by the UK government to test the resilience of its power and gas networks in a range of future conditions. The scenarios provide both historical and projected information to 2100 for the UK, based on climate change simulations from the Met Office's Hadley Research Centre.[7] The scenarios include observed 20th- and 21st-century data about temperature, precipitation, storms, sea-surface temperatures, and sea level; future projections for temperature, precipitation, air pressure, clouds, and humidity; and projections for sea-level rise, storm surge, sea-surface and sub-surface temperature, currents, and waves.

National Grid chose to evaluate its assets and business practices against impacts projected in the highest level of greenhouse gas emissions by 2080 (the worst-case scenario), since resilience against the worst-case scenario would also ensure resilience to less severe and more likely future changes. It converted information from the UK scenarios (UKCP09) on temperature, rainfall, and sea-level rise; Met Office studies on the energy sector; and insights from its own engineers into a set of Specific Physical Characteristics that could pose risks to the company. National Grid's Adaptation Risk Assessment process (**Figure 1**) then applies each physical characteristic to key assets and business processes (**Figure 2**). The analysis also evaluates changes in markets, for example, increased demand for cooling during longer, hotter summers and reduced demand for heating during shorter, milder winters. Risks and action steps are prioritized according to the level of certainty about the impact and internal evaluations of current resilience based on industry and engineering standards for power equipment and networks.

The results of this analysis indicate to the company that it has a good understanding of, and resilience to, the risks posed by future climate changes. The yellow and amber cells illustrating gaps in knowledge and resilience are analyzed for when and how the impact could affect the company and communities, and action steps are proposed to mitigate the risk (**Figure 3**). Priority risks—namely, higher temperatures, stronger storms,

FIGURE 1: National Grid's Climate Change Risk Assessment Methodology



Source: National Grid Electricity Transmission, 2010

and flooding from storms or sea surges—are integrated into National Grid's core risk reporting process in which the risks are assessed, mitigation actions determined, and both reviewed quarterly. The company's overall adaptation strategy is kept under continual review by the corporate climate change team, and updates on flooding risks are provided annually to the company's Executive and the Risk Responsibility Board Committees.

In the United States, National Grid's efforts to anticipate and mitigate risks from extreme weather are not necessarily organized around "adaptation" or even "climate change." There are still questions—both within the company and among U.S. state regulators—about whether recent extreme weather is attributable to climate change and indicative of a "new normal." Given this uncertainty and the lack of any federal mandate, should the company spend more to harden power and gas systems? If National Grid does invest in system upgrades, and the unusual weather subsides, will they be punished by state regulators and shareholders? What is the best information to use to justify investing in greater system resilience? The company's efforts to answer these questions are more decentralized in the United States than in the UK and involve on-the-ground teams working directly with state regulators, communities, and industry groups on local impacts and relevant strategies.

A review by U.S. staff of the research conducted in the UK did help to highlight river and sea-surge flooding as a priority item for further review. Projections by the UK Met Office of more frequent and costly floods echo what National Grid is already experiencing in the northeast United States. As a result, the primary focus of the company's work with state-level task forces—including the New York State Sea Level Rise Task Force, the Massachusetts Adaptation Advisory Committee, and the New York City Mayor's Climate Adaptation Committee—has been on flood risk assessment and mitigation.

In one example, National Grid conducted a year-long assessment of potential future flood risks to all of its electricity substations in Rhode Island following damage from major river floods in March 2010 that reached 2 to 6.5 feet and inundated eight out of 67 substations.[9] Inland and coastal flood zone maps from the Federal Emergency Management Agency (FEMA) were overlaid on the boundaries of the company's substations, with special consideration given to those that had been affected in the past. Elevation and other data discrepancies were resolved through on-the-ground field surveys. Based on the findings, National Grid plans to rebuild parts of its substations, or elevate specific equipment within substations, in areas susceptible to flood conditions, investing nearly $23 million over the next five years. Similar assessments are underway for electric substations located within National Grid's service territory in Massachusetts and upstate New York.

National Grid's gas utility service also reacted to the significant flooding event in 2010. A number of flood-affected areas were identified in the New England service areas, which prompted review of geographic information system (GIS) and FEMA flood information. Sensitive areas had previously been identified in locations where low-lying areas susceptible to flooding would potentially be affected by coastal storm surge. Additional review now looked into areas where assets and infrastructure may be vulnerable also to flooding of rivers and streams. The company's existing System Reliability Programs evaluated vulnerable assets and resulted in several projects planned for execution over a multi-year period, including relocation of critical assets outside of the floodplain and storm hardening of existing facilities that were not able to be readily moved to higher ground. Several projects have been identified in the plan for Westerly, Rhode Island.

FIGURE 2: Summary of Climate Adaptation Risk Assessment Process for National Grid Electricity Transmission

	SPECIFIC PHYSICAL CHARACTERISTICS OF CLIMATE ADAPTATION SCENARIOS								
	UKCP09 Characteristics			Met Office Characteristics				NG Characteristics	
Key Assets and Processes	**Solar Heat—Temperature rise of up to 8C**	**Increased Heavy Rainfall (by a factor of 3.5)**	**Sea Level Rises of up to 43cm**	**Increased Lightning**	**Increased Wind and Gale**	**Increased Snow, Sleet, Blizzard, Ice and freezing fog**	**Increased Flooding**	**Increased Coastal/River erosion**	**Increased Subsidence**
Included in National Grid Risk Management Process	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Assets									
Substation Sites (Incl. switchgear, transformers, earthing)	●	●	●	●	●	●	●	●	●
Expansion of Existing Substation Sites (outside of existing boundary)	●	●	●	●	●	●	●	●	●
Existing Tunnels and Underground Cable Routes	●	●	●	●	●	●	●	●	●
Existing Cable Bridges	●	●	●	●	●	●	●	●	●
Existing Overhead Lines (OHL) and Towers	●	●	●	●	●	●	●	●	●
New Sites (Substations, OHL, Tunnel Heads, Cable Sealing Ends)	●	●	●	●	●	●	●	●	●
Processes									
Emergency	●	●	●	●	●	●	●	●	●
Maintenance, Construction & Fault Repairs	●	●	●	●	●	●	●	●	●
Control Center Operations	●	●	●	●	●	●	●	●	●
Office Staff	●	●	●	●	●	●	●	●	●

● **Green:** no material risk
● **Yellow:** a currently controlled risk, additional investment may be required
● **Amber:** a risk requiring further information
● **Red:** a likely future significant and not currently controlled risk

Source: National Grid Electricity Transmission, 2010.[8]

The Gas Systems Engineering Group has also developed the Water Intrusion/Washout Program. This program was initiated in 2010 as a result of the heavy rainstorms and flooding that occurred across the service territory in March and April of that year, extreme weather that caused a number of outages when water entered into low-pressure distribution systems. Year over year, water intrusion may fluctuate due to weather and other environmental factors, driving the need for additional replacements and spending. The program creates a mechanism to fund emergent work as issues are identified throughout the year. In the unlikely event that no emergent work is identified, funding will be reallocated to the replacement of leak-prone pipe, with a focus on flood-prone areas, and efforts to upgrade system pressures where higher-pressure systems are available.

National Grid strategic planners and engineers have also begun to integrate expectations of more frequent and damaging floods into the design and future placement of power and gas infrastructure over the next 10, 20, and 50 years. For example, following the company's Rhode Island flood risk assessment, substation design criteria were revised to avoid locating new substations in flood zones, to ensure elevations of at least 24 inches above 100-year flood levels, and to consider relocating them out of flood zone areas during major upgrade projects. In other cases,

FIGURE 3: Excerpt of Yellow and Amber Risks and Action Steps Identified, from Risk Assessment Matrix

BUSINESS FUNCTION	CLIMATE VARIABLE (E.G. INCREASE IN TEMPERATURE)	PRIMARY IMPACT OF CLIMATE CHANGE VARIABLE (E.G. HEALTH)	THRESHOLD(S) ABOVE WHICH THIS WILL AFFECT YOUR ORGANIZATION	LIKELIHOOD OF THRESHOLD(S) BEING EXCEEDED IN THE FUTURE AND CONFIDENCE IN THE ASSESSMENT	POTENTIAL IMPACTS ON ORGANIZATION AND STAKEHOLDERS	PROPOSED ACTION TO MITIGATE IMPACT	TIMESCALE OVER WHICH RISKS ARE EXPECTED TO MATERIALIZE AND ACTION IS PLANNED
Substation sites (including Switchgear, transformers and earthing)	Increased Temperature	Ratings	Temperature increases may have a marginal impact on equipment ratings. More work is required to better understand the potential impact.	More work is required to better understand the potential impact and the likelihood of threshold being exceeded.	Possible reduction in the flexibility of the network. More work is required to better understand the constraints which this may bring, also studies are required to understand if normal system growth would offset any loss in resilience.	Studies to better understand the constraints which this may bring, and identify possible weaknesses in the system. Also studies are required to understand if normal system growth would offset any loss in resilience.	It is not anticipated for risks to materialize within the next 20–40 years. Initial studies to confirm the risks are anticipated to be completed by 2012.
Substation sites (including Switchgear, transformers and earthing)	Increased Flooding and Heavy Rainfall	Pluvial and Fluvial flooding There is a risk that due to extreme flooding a site may be lost or unable to function leading to reduced system security of supply.	Most sites have a resilience to flooding to an approximate depth of 300mm. Each site has been assessed to better understand the projected flood frequency and possible impact of flooding on each site.	In line with ETR 138 National Grid Electricity Transmission plc has assessed the flood risk of all substations in line with EA and AOD data. 13 sites have been identified as being at risk from a 1 in 100 flooding event.	A site may become non-operational due to sea inundation potentially leading to a loss of system resilience or a loss of supply. A non-operational site may not lead to a loss in supply.	National Grid Electricity Transmission plc has embarked on a prioritized investment plan to defend sites to 1 in 200 or 1 in 1000 year flooding event dependant on cost benefit analysis and societal risk. In the interim National Grid has invested in a demountable mobile defense system of 1.2km.	Investment is targeted for completion on all sites by 2022 beginning with the 1 in 100 risk sites.

Note: ETR 138 refers to an Engineering Technical Report produced in 2009 by the Energy Networks Association on flood resilience of electricity substations. EA data is data provided by the UK Environment Agency, and flood defenses are measured in terms of maximum water levels above Ordnance Datum (AOD).

Source: National Grid Electricity Transmission, 2010.

historical records of past power outages and extreme weather were analyzed to inform decision-making about system retrofits and upgrades. For example, expectations of stronger storms and floods are influencing cost/benefit calculations for the addition of utility poles or their replacement with steel structures instead of wood.

Risk Management: Supplementing Business as Usual

As a result of these risk analyses, National Grid finds it has a good understanding of, and resilience to, future climate change impacts.[10] Anticipating and managing the effects of weather is already a fundamental part of its business continuity and emergency response capabilities.

Power networks and gas infrastructure, built to industry-wide standards, are already resilient to a significant level of extreme weather. And the priority risks and costs identified by National Grid's climate risk analysis—higher temperatures, stronger storms, and flooding from storms or sea surges—are factored into existing risk and compliance processes.

In response to the recent increase in extreme weather and pressure from regulators in the United States and UK, National Grid is undertaking a number of additional risk assessments and activities that will help harden systems to more severe weather conditions. After the major UK floods in 2010, it conducted a flood risk assessment of more than 130 electricity substations using data from the UK Environmental Agency on river and tidal flood risk. From an initial set of 47 sites identified at risk from 100-year floods, 13 were prioritized based on more detailed site surveys and on what it would cost to protect the sites. The company plans to rebuild or elevate parts of these substations by 2022. Coastal erosion risks to substations have also been monitored since 2009, in particular 57 substations located in zones that could be at risk according to the UK Environmental Agency's shoreline management plans. In 2009–2010, National Grid Gas initiated a program to evaluate the impact of flooding on pipelines and pressure-reduction equipment.[11]

In addition to preparing for long-term changes in extreme weather and climate, the company is also modifying its storm response planning and procedures to keep up with the unexpected frequency and variety of weather events. In the United States, its storm response strategy is now more centralized and coordinated across the legacy gas and electricity businesses. After Hurricane Irene and the October 2011 surprise snowstorm, National Grid expanded contracts to bring in additional engineers and response crews from outside the Northeast when needed. The company has brought on two Massachusetts Institute of Technology (MIT) students to build a potential damage index tool that would examine historical weather and outage data in parts of Massachusetts and determine how adverse weather affects the electrical distribution system. The team will analyze prevailing wind direction and speed, precipitation, lightning, and time of year in various areas such as higher geographies (e.g., the city of Worcester) and coastal areas (e.g., Cape Ann or South Shore) for their impact on distribution system performance. National Grid will use the results of this study and weather forecast data to enhance its emergency response planning process, needs assessment, and event classification.

As part of the company's effort to improve its response to weather emergencies, it has pre-defined roles for all employees to perform an emergency response assignment. The company designated and trained certain employees to act as community liaisons, where they serve as the conduit between municipal officials and the company to help restoration efforts by setting and communicating priorities within the community. Many of these practices were adopted from the experiences of peer utilities in Florida and along the Gulf Coast that have been historically hard-hit by hurricanes.

CHALLENGES AND BARRIERS

National Grid's experience highlights that current assumptions about weather risk in the utility industry can be overwhelmed by unexpected events, calling into question a company's short- and long-term response and planning strategies. It also highlights the very different ways that risk planning and response can evolve under different cultures and governments. The UK government is playing a proactive role in coordinating a national response to climate change impacts, requiring key industries to assess risks and prepare, while providing centralized repositories of information, data, and tools.

National Grid in the United States has worked with other utilities in industry groups and with state regulators to develop local responses to local threats. The company emphasizes the importance of working and sharing information with state environmental departments and utility commissions, to ensure that its investment in hardening systems is commensurate with the expected level of risk. Given the critical role of state utility commissions in approving rates and expenditures, these efforts will become increasingly important over time.

In both markets, the company seeks to identify and apply the best possible information about the types of extreme weather and climate changes to expect. And the information needs to be regionally specific enough to be useful. Publicly available information in the UK has been invaluable in completing National Grid's climate risk analysis. National Grid has noted several areas that are not typically available from climate models and would be helpful for future study in the UK including, for example, potential changes in the frequency or intensity of lightning, wind and gale, snow, sleet, blizzards, ice, and freezing fog, and absolute values or ranges of data in

addition to incremental values from historical trends.[12] National Grid in the United States has made use of publicly available flood maps, but notes that these are in need of being updated and the historical information about past trends is not a complete picture of future conditions under the magnifying effects of climate change. Internally collected data on, for example, wind gusts or power outages, is also backward-looking and is not always gathered consistently or over a long enough period of time to support decision-making.

ENDNOTES

1 Massachusetts state officials levied fines against three power companies, citing failures in preparation and response to Hurricane Irene and the October "surprise" snowstorm, which caused extensive damage to large swaths of the state. Peter Schworm, "State Fines 3 Power Providers $25m," *The Boston Globe*, December 11, 2012.

2 David Bertola, "National Grid Keeps Tabs on Power Usage," July 22, 2011, *Buffalo Business First*. During record-high temperatures, upstate New York used more than 7,000 megawatts (MW) of power from 3 p.m. to 4 p.m., beating the previous record for use in one hour of 6,915 MW set on July 8, 2010. Factories contribute to increased demand in hot weather, where equipment needs to work harder. "The fact that we set a record is not a huge surprise, it very much fits the pattern," said a National Grid spokesman.

3 Part of the UK Climate Change Act (2008) requires the Secretary of State to carry out an assessment of the risks to the country from climate change impacts. The Secretary is directing companies with functions of a public nature such as water and energy utilities to report on how they are assessing and acting on the risks and opportunities from a changing climate.

4 A similar national research effort is underway in the United States: the U.S. Global Research Program's National Climate Assessment (NCA) will be publishing a comprehensive analysis of climate change impacts, by U.S. region and industry sector, at the end of 2013.

5 More information is available at http://www.metoffice.gov.uk/services/climate-services/case-studies/energy. The UK Met Office is also currently conducting a study, based on a version of the UK government's climate scenarios downscaled to 25 kilometer areas, to determine the set of current baseline risks to the national electricity network from weather-related damage and interruptions from local impacts such as lightning, snow, ice, and high winds.

6 The first assessments were presented to the UK Parliament in January 2012 and will be updated every five years.

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10 National Grid Electricity Transmission plc, *Climate Change Adaptation Report*, September 2010.

11 National Grid plc response to Carbon Disclosure Project Investor Survey 2012.

12 National Grid Electricity Transmission plc, *Climate Change Adaptation Report*, September 2010.

CASE STUDY: RIO TINTO

CASE STUDY	RIO TINTO
Headquarters:	London, United Kingdom
Industry:	Mining & Processing
Revenues (2012):	$15.5 billion
Employees:	120,000
Key Initiatives:	• Developing climate change scenarios and business implications for key regions • Engaging in research partnerships that are analyzing climate change impacts • Building climate risk awareness and expertise among business units and staff

COMPANY PROFILE

Rio Tinto is a leading international mining group strongly represented in Australia and North America and with operations in Asia, Europe, Africa, and South America. Founded in 1873, Rio Tinto's business is finding, mining, and processing mineral resources, including aluminum, copper, diamonds, thermal and metallurgical coal, uranium, gold, industrial minerals (borax, titanium dioxide, and salt), and iron ore.

BUSINESS DRIVERS AND INITIAL CONCERNS ABOUT IMPACTS OF CLIMATE CHANGE

As a global, vertically integrated business, Rio Tinto is exposed to the impacts of extreme weather and climate change across a wide spectrum of business activities—from mining and processing to power plant operations, transportation, and logistics. Heavy rainfall and associated erosion may affect ground stability near mines. Hotter and drier conditions increase wildfire threats to facilities, and rising sea levels may make coastal operations harder to access. Transporting product by road, rail, or sea can be interrupted by cyclones, floods, and even warmer temperatures. The company's power generation and transmission operations can also be disrupted, for example, by significant changes in water availability.

Mines and Facilities

Extreme weather is already impacting Rio Tinto's bottom line. Iron ore and metallurgical coal production dropped sharply—by 3 percent and 12 percent, respectively, in the first quarter 2011—when record flooding in north Australia and excessive rainfall, swells, and winds from cyclones on the east and west coasts overwhelmed systems and caused a train derailment.[1] A year later, powerful cyclones hit facilities and damaged infrastructure, particularly affecting coal, iron ore, bauxite, and uranium operations in western Australia, Queensland, and the Northern Territory. Weather-related disruptions to mines and ports caused a 10 percent drop in iron ore production in the first quarter of 2012.[2]

Flooding from increased rainfall not only interrupts production, but may also require additional controls on water treatment. In January 2011, Rio Tinto's uranium subsidiary, Energy Resources of Australia (ERA), a publicly listed company, suffered its largest one-day share price drop in more than two years after higher-than-average rainfall forced the company to stop plant processing at the Northern Territory mine for three months to ensure that water in a tailings storage facility remained at the required level. Heavy rains flooded pits at ERA's Ranger mine, raising fears of a contaminated water

spill into the World Heritage–listed tropical wetlands surrounding it. ERA's decision to shelve an expansion project was also related, in part, to the water problem.[3]

Rio Tinto uses large volumes of water in its operations, during exploration, mining, processing, smelting, refining, rehabilitation, and generation of hydroelectric power. While floods are a risk in certain locations, the company also anticipates that warming temperatures may increase water scarcity in some locations, possibly impacting operations and increasing competition for limited water resources (**Box 1**).[4]

Supply Chain

Heavy precipitation, drought, warmer temperatures, and sea-level rise have the potential to impact Rio Tinto's ability to supply goods and services, transport personnel, and move raw materials to its processing facilities (and to ports for export). Operations in subarctic regions, for example, rely upon critical supplies that are carried seasonally over winter ice road networks. Warming temperatures and permafrost thaw shortens the amount of time available for safe transport over ice roads, interfering with consistent and timely delivery of supplies and limiting production capacity at Arctic sites. In 2006, due to permafrost thaw, Rio Tinto's Diavik diamond mines had to fly in diesel fuel supplies rather than transport them over the ice roads, costing the company an extra $11.25 million.

Energy and Water

Mining operations—particularly smelting and mineral processing—are energy-intensive. In addition to depending on the power grid for electricity, Rio Tinto owns and operates several power plants to supply electricity to its mining, smelting, and refining operations. Like all energy-dependent companies, Rio Tinto is vulnerable to power disruptions from severe weather and floods. Warmer temperatures may also increase energy needs for cooling underground mines and surface facilities.

Two-thirds of Rio Tinto's energy use—516 petajoules in 2011[5]—comes from hydroelectric, nuclear, and renewable sources such as solar power. Hydropower makes up a considerable portion of Rio Tinto's power generation, with a total capacity of 3,972 MW at facilities in Canada, Scotland, and Norway. In the first half of 2010, Rio Tinto reported that low snow and rain levels in the Saguenay region of Quebec led to reduced power generation and subsequent need to either purchase power or curtail aluminum production. Though projections for long-term changes in rainfall, snowfall, and water availability are uncertain, particularly in North America, increases or decreases in water supply have the potential to disrupt Rio Tinto's energy supply and production capacity.

Business Drivers

Climate extremes—unexpected storms or floods significantly more severe than past experience—can have greater impacts than incremental average changes. Relying on past experience of weather as representative of future change is no longer sufficient. Rio Tinto's recognition of this is driving greater attention toward integrating climate change factors into risk management and business planning.

Stakeholder and investor pressures have also exerted influence on Rio Tinto's perception of climate risk. Rio Tinto participates in the Carbon Disclosure Project's annual surveys of the regulatory, physical, and business risks from changing climate and water resources, conducted on behalf of over 700 institutional investors holding $87 trillion in assets. The increasing sophistication and breadth of the survey questions—from identifying risks, to how they are managed and their financial implications—illustrates continued interest from stakeholders for information on company actions to address these risks.

Box 1: Regulatory Responses

Rio Tinto has already encountered emerging regulatory responses to the physical impacts of a changing climate. Some states in Australia are updating their processes for environmental impact assessment and approval to include more climate change considerations than in the past. States that are currently experiencing significant periods of drought have become more sensitive to how future climate changes will exacerbate water scarcity and how large water users are managing resources. While the full implications of these steps are not yet clear, Rio Tinto recognizes the possibility of increasing regulatory requirements in the future with respect to water planning processes.

COMPANY RESPONSES

Rio Tinto has a common standard for risk analysis and management that incorporates a range of health, safety, environmental, and other factors into decision-making. Company-wide standards provide guidance for this risk analysis (**Box 2**). Extreme weather has always been an important business issue for Rio Tinto, and existing risk analysis and business planning processes are beginning to integrate a better understanding of how a changing climate will alter those risks.

Risk Assessment: Climate Modeling and Studies

A key challenge for the development of a framework for climate change risk analysis is the need to tailor information to business type and location. Each of Rio Tinto's businesses and assets has unique risk characteristics and exposure profiles, for example, excessive rainfall and flooding will affect mines and smelting facilities differently. In regional terms, mines in western Australia, which are frequently subject to cyclones, have a different risk profile than mines in Namibia, where water is scarce. Rio Tinto's challenge is to develop a detailed enough picture of risks across a broad range of assets and geographies to allow business units to develop and implement effective local strategies.

Rio Tinto's corporate Energy, Environment and Climate Change group has been evaluating risks to the business from a changing climate since 2002. Risk assessment started with a high-level "desk-top" study of potential impacts to operations, by region, using climate change projections from the Intergovernmental Panel

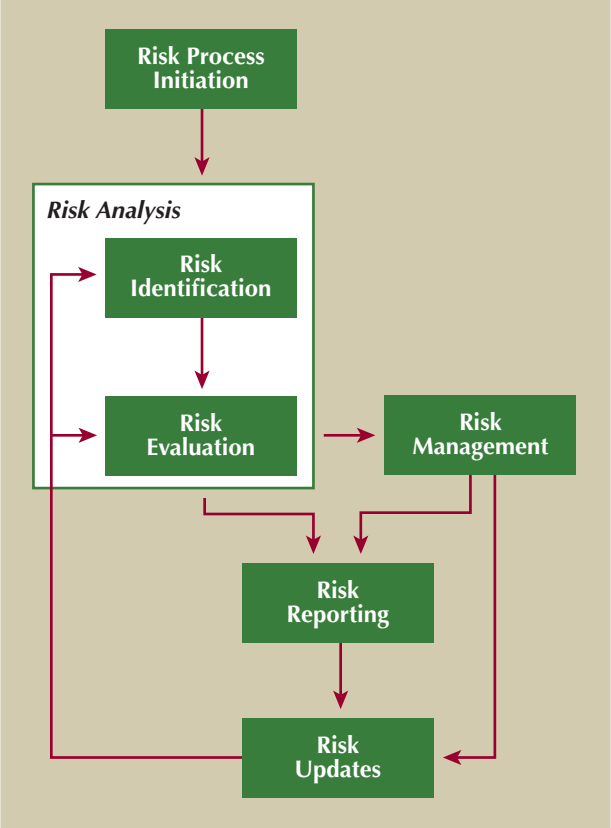
Box 2: Risk Analysis and Management Process

Rio Tinto's risk analysis and management follows a uniform process to ensure consistency and high quality across its business units. The process includes six elements: risk process initiation, risk identification, risk evaluation, risk management steps, risk reporting, and risk updates (see figure). Thresholds for what constitutes acceptable levels of risk are defined with scales for both likelihood and consequences. Risks are then assessed and classified along the thresholds into one of four of Rio Tinto's risk management classes:

- Class I: Risks that are below the risk acceptance threshold and do not require active management
- Class II: Risks that lie on the risk acceptance threshold and require active monitoring
- Class III: Risks that exceed the risk acceptance threshold and require proactive management
- Class IV: Risks that significantly exceed the risk acceptance threshold and need urgent and immediate attention

All risk analyses must consider the following five types of economic consequences, all of which have a direct effect on value: capital expenditure, schedule, operating cost, production volumes, and revenue. Non-economic consequences are also considered, including personnel safety, health impacts, environmental impacts, community impacts, compliance impacts, and business reputation. The results of the risk analysis process are documented and reported to key stakeholders.

Rio Tinto Risk Analysis and Management Process



Source: Rio Tinto 2009.[6]

on Climate Change (IPCC)'s 2001 Third Assessment Report[7] and phone interviews with regional business managers. This exercise helped to identify a broad range of relevant risks, but was insufficient to fully understand their magnitude and implications. In 2005, a second study with the Hadley Centre for Climate Change in the UK developed a more detailed picture, based on national data, of how changes in key climate variables over the next 25 to 50 years might affect regions where the company operates. These studies considered changes in extreme weather events, in addition to changes in average temperatures and weather conditions, and indicated that, while climate changes will be minimal in the near term, they are likely to increase over the longer term and vary by location.

Limited climate change projections available at that time left a considerable degree of uncertainty, and business units lacked sufficient information to fully understand how the climate was likely to change in their region. Between 2008 and 2010, Rio Tinto initiated a partnership with climate scientists affiliated with the University of Oklahoma, investing approximately $600,000 to develop more detailed projections of climate change impacts for specific operating sites selected for their remaining life, their prospective developments and expansions, and their location in climate-sensitive parts of the world. Assessments for seven regions were conducted using high-resolution climate models (down to 20 kilometer by 20 kilometer grids), which are able to provide some indication of changes in cyclone activity and topographic effects.[8] The outputs from these climate modeling studies were used to analyze how specific, discrete climate-related risks, such as changes in water availability, might evolve and to evaluate possible company responses.

In addition, the Energy, Environment and Climate Change group developed guidance to describe how business units can apply the company-wide risk analysis process (Box 2, above) to energy and climate change risks. This guidance serves as a tool to better understand the kinds of physical climate issues that businesses need to consider and as a platform to build expertise, capacity, and resilience strategies over time.

Risk Management: Building Adaptive Capacity

Rio Tinto is focused on building adaptive capacity—developing skills, collecting information, and evaluating management options—that will position it to learn and adapt in the longer term. Senior executives received a briefing from the Hadley Centre on key developments in climate science and their business implications. Guidance has been developed that provides a framework for building adaptive capacity over time so that business objectives can continue to be met in a changing climate.

In addition, weather forecasts are increasingly being used by the company to improve climate resilience and preparedness in the short to medium term, which will also assist in building capacity to deal with changes long term. Long-term planning and lessons from past weather events are already built into business continuity and site planning procedures, and these are being supplemented with climate change projections over longer time horizons. Operating sites are beginning to consider the physical risk of climate change by including:

- Climate projections in water management programs, such as the long-term assessment of sustainable water supplies and risk of future floods
- Climate change in the engineering design of new projects, so that they are sufficiently robust for extreme events that will likely occur
- Climate change variables in disaster management planning
- Potential climate change impacts in ice road design and contingency planning[9]

No single approach can be adopted across every business unit to prepare for, or recover from, extreme weather events or climate change impacts. Consequently, business units and regional operations are beginning to develop plans and responses that are location-specific (**Box 3**). For example:

- To better manage the impacts from storm activity and flooding on Australia's east coast, Rio Tinto Coal Australia uses site-specific weather forecasts to provide a shorter-term, three- to seven-day pictures of risks, in order to anticipate and prepare for a higher probability of significant rainfall. It is also working with regulators to better link water management requirements with expected seasonal conditions.
- A seasonal tropical cyclone outlook for the Australian region is being used to help business units to prepare for upcoming cyclone seasons. This supplements existing business initiatives, such as the use of site-specific weather forecasts that provide key decision-making metrics to operations managers.

In 2005, Rio Tinto developed a company-wide water strategy to respond to droughts and floods, partly as a

Box 3: Rio Tinto Alcan

Rio Tinto Alcan, one of the world's largest producers of bauxite, alumina, and aluminum, has developed a Climate Change Sensitivity Framework to assess the exposure of operations and associated infrastructures to climate change risks, particularly for acquisitions and divestments. The framework is intended to form a picture of risks related to, for example:

- Vulnerability of land, sea and river transport systems
- Disruptions to supply chains and logistics
- Potential for increased maintenance requirements and degradation of assets that have been designed on the basis of historical climate data and periods of relatively stable weather
- Potential for downtime and disruption to operations from extreme weather events that exceed engineering or operational standards
- Changes in power generation capacity
- Site-specific operational risks including exposure to higher temperatures resulting in increased drought risks, or low lying coastal areas at increased risk of flooding[10]

The framework is not intended to predict future change by quantifying and reducing the uncertainty of climate projections. It recognizes that some uncertainties associated with projected climate change are irreducible, and takes account of a range of potential future greenhouse gas emissions scenarios. The framework also includes a matrix that prioritizes the risks to be addressed. "Instead of a top-down methodology that attempts to foresee the future, Rio Tinto Alcan is building a bottom-up approach that increases the group's capacity to deal with the unexpected."[11] The company has also entered into a $500,000 research partnership with a Canadian consortium working to better understand the regional impact of climate change on the Lac Saint-Jean basin in Quebec over the coming years. This joint effort aims to better understand the impact of climate change on Rio Tinto Alcan's water resource management operations, as well as improve hydrological forecasting in the short and long term.

result of what it has learned about climate change. A company-wide water standard outlines minimum expectations for water management at all operating sites, from the exploration stage to mine or facility closure, and a corporate water target calls for a 6 percent reduction in freshwater use per tonne of product by 2013 from 2008 levels. Each site's management plan outlines key issues, water accounting systems, the actions to mitigate the risk, and the personnel involved. This plan is linked to the site's overall business planning process, to ensure that appropriate budget is allocated for water management.

CHALLENGES AND BARRIERS

One of the most difficult challenges for Rio Tinto is implementing operational change across sites with very different risk characteristics, and doing so on the basis of climate model projections that are uncertain with regard to the nature and timing of future impacts. The timeframe for expected impacts has also posed a challenge—a sound policy must address both the near-term risks associated with extreme weather and the more uncertain but dramatic long-term changes in climate. Rio Tinto is approaching the challenge by framing "climate risk" as business planning actions that they can take in the short term, specifically to understand risks and build adaptive capacity, that will also position it to better manage risks and strengthen competitiveness over the next two to three decades.

Rio Tinto has recognized the need to look ahead to see what changes in extreme weather are likely and not to assume that events in the future will be the be similar to those in the past. A critical need in this effort is climate impact projections that are able to be translated and applied within business frameworks and processes. Stronger connections between the scientists generating the information with business decision-makers would help to ensure that data and information are tailored to the end-users' needs. Information needs to be detailed enough to be meaningful, while avoiding the caveats and uncertainty ranges that obscure the overall picture of risk to the business.

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CASE STUDY: WEYERHAEUSER

CASE STUDY	WEYERHAEUSER
Headquarters:	Federal Way, Washington
Industry:	Financial/Real Estate Investment Trust; Industrial goods
Revenues (2012):	$6.2 billion
Employees:	12,800
Key Initiatives:	• Utilizing forecasting models and sensing technologies to detect early indications of climate changes • Engaging in research partnerships that are analyzing climate changes • Developing more resilient tree species and forest management practices

COMPANY PROFILE

Weyerhaeuser Company, one of the world's largest forest products companies, grows and harvests trees, builds homes, and manufactures forest products such as lumber, wood and building products, and pulp and paper. Weyerhaeuser has a worldwide presence: it manages 20.3 million acres of timberlands in nine U.S. states, three Canadian provinces, and in Uruguay and China; it operates wood products and cellulose fiber mills in the United States and Canada; and it conducts residential real estate operations in seven U.S. states. The company's timberland, wood products, and cellulose fibers businesses made up a majority of its $6.2 billion in 2011 annual revenues.

BUSINESS DRIVERS AND INITIAL CONCERNS ABOUT IMPACTS OF CLIMATE CHANGE

Climate and weather directly and indirectly affect the growth and productivity of forests. Extreme weather events such as storms, droughts, and floods can damage trees, especially during replanting when seedlings are small. Changes in climate—higher air temperatures, changes in precipitation, longer and more frequent droughts—influence the structure and function of forest ecosystems and can increase the likelihood of "disturbance events" such as insect outbreaks, spread of invasive species, wildfires, and severe storms.

Under typical conditions of variability, most tree species are somewhat resilient to increases in air temperature or changes in precipitation over time. But climate change is expected to make future droughts and storms more severe and damaging than those experienced in the past. Warmer temperatures alter the timing of snowmelt and may affect the seasonal availability of water, and they may lengthen the growing season or shift the geographic range of some tree species. Rising temperatures may enable some insect species to develop faster and expand their ranges, and insect outbreaks can defoliate, weaken, or kill trees. A mountain pine beetle outbreak, for example, damaged more than 3.8 million acres of forest in the western United States and spruce beetle outbreaks have resulted in the loss of an estimated 3 billion board feet of timber in Alaska over the past three decades.[1] Warmer spring and summer temperatures, along with decreases in water availability, also dry out woody materials in forests and increase the risk of wildfires. These disturbances can interact with one another to increase overall risks to forest productivity.

In December 2007, a series of snow, wind, and rainstorms battered western Oregon and Washington—where

over one-third of Weyerhaeuser's timberlands are located—causing severe flooding and wind damage. A small portion of Weyerhaeuser's timberlands received extraordinarily high rainfall and suffered hundreds of landslides, renewing discussions with communities about the effects of tree harvesting on steep slopes. The company's manufacturing facilities for wood products and fibers can also be vulnerable to severe weather and changes in climate, for example, the company has wood processing facilities located in hurricane-prone regions of the southeastern United States. Pulp and paper manufacturing also requires large volumes of water, potentially making the company vulnerable to significant reductions in water quality and supply.

Weyerhaeuser also hears concerns from its customers and investors about climate change–related risks. Some of its largest customers, such as Procter & Gamble, survey their suppliers to better understand how they are addressing climate and sustainability risks. Weyerhaeuser also participates in the UK-based Carbon Disclosure Project's annual survey, on behalf of 700 institutional investors holding $87 trillion in assets, of the regulatory, physical, and business risks from a changing climate.

COMPANY RESPONSES

Climate and weather factors have always been integrated into Weyerhaeuser's business planning, risk assessment, and core management operations, particularly for the timberlands business. Weyerhaeuser has more than a century of experience with understanding the impacts of weather and climate on forests, and managing those to maximize yield. The company's continual risk assessment and adaptive management processes are critical for building resilience to the effects of climate and weather, and incorporating climate change factors into these processes only reinforces to Weyerhaeuser the importance of its existing efforts and approaches. Drawing on this expertise, the company is also beginning to help other industries adapt to changes in climate and weather.

Risk Assessment: Continual Monitoring and Review

Climate and weather risks are part of Weyerhaeuser's broader corporate climate change strategy (**Box 1**). Climate and energy trends are included in the company's periodic capital investment and corporate direction-setting process, which considers a broad set of future scenarios.

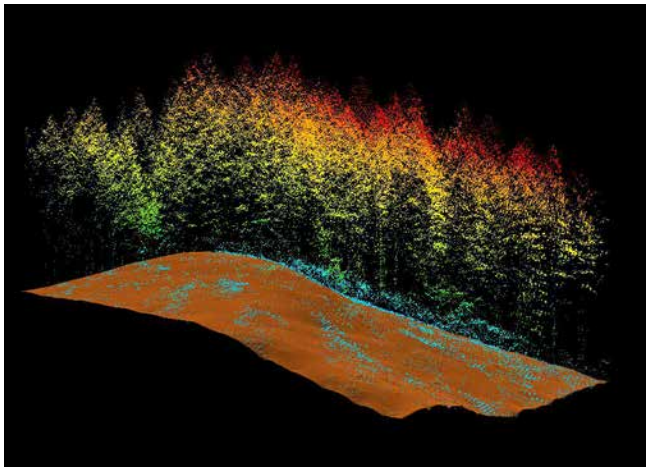
In Weyerhaeuser's timberlands business, a centralized strategic planning group uses geographic- and species-specific forecasting models and light detection and ranging (LiDAR) technologies (**Figure 1**) to examine the relationship of local and regional climate changes to long-term forest growth and yield. The company's in-house staff of hydrologists, pathologists, and other experts conducts extensive research on the ground to collect real-time environmental data, and key findings are incorporated back into the central planning models. These models are based on historical data, incorporating over five decades of research, and quantify risks by region based on past trends. For much of its risk management analysis, Weyerhaeuser relies on close monitoring of existing conditions that affect its timberlands, allowing it to quickly identify changes in underlying climate and weather conditions and any associated potential impacts.

This continual risk assessment process provides an early indication of changes in the growing environment, enables the company to assess possible vulnerabilities to shifts in climate, and guides its responses and adaptive management practices. For example, Weyerhaeuser anticipates that continued favorable precipitation patterns in Washington and Oregon will keep wildfire risks to

Box 1: Corporate Climate Strategy

Weyerhaeuser has a Climate Change Steering Team made up of technical, scientific, and policy managers to guide the company's strategy, positions, and goals on climate change issues. The company has outlined 43 sustainability metrics and goals to achieve by 2020 and uses a business scorecard to track progress. One of the company's goals is to reduce greenhouse gas emissions by 40 percent by 2020, compared to a year 2000 baseline. Other goals include adopting sustainable forestry standards, better managing water resources, and enhancing ecosystem services, among others.[2] The Governance and Corporate Responsibility Committee of the company's Board of Directors has responsibility for oversight of the sustainability strategy and receives regular updates on the company's sustainability performance.

FIGURE 1: LiDAR Sensing Technology



Weyerhaeuser uses LiDAR sensing technology to better understand stand structure and development. This image shows the forest canopy at different heights above the ground.

Source: Weyerhaeuser 2012.[3]

a minimum, but that warmer winter temperatures in Oregon may lead to greater outbreak of the Swiss needle cast disease affecting foliage. The Oregon Department of Forestry estimates that, as winter temperatures continue to rise, forest growth losses in Swiss needle cast epidemic areas could exceed $200 million per year.[4]

In addition, Weyerhaeuser participates in research efforts that seek to advance the current understanding of emerging risks. Weyerhaeuser's timberlands business engages in research partnerships with universities, government agencies, and others to better understand the possible physical risks from a changing climate. The company participates in the Swiss Needle Cast Cooperative led by Oregon State University, which is studying, among other issues, the impact of potential climate changes on the foliage disease. Weyerhaeuser has also participated in scenario planning initiatives in Washington state to understand the long-term affects of climate change in the region. As part of the company's larger water conservation effort, it initiated a long-term study in 1999 to determine the effect on water systems and quality of converting grazing land in Uruguay into forests. This study is being conducted in collaboration with North Carolina State University, the federal agricultural research agency in Uruguay, and a major research university in Montevideo. The study will help determine the impacts of land use (including managed forestry or biomass crops) on water supply and the quality of drainage water.[5]

Risk Management: Adaptive Management Practices

Over time, Weyerhaeuser has developed robust management responses to build resilience across the growing cycle of its timberlands—from planting to final harvest—against losses from storms, pest infestation, wildfires, and drought. The company regularly updates its forest timber inventories, growth projections, harvest schedules, and planting activities to account for potential and actual annual losses from extreme weather. The company locates its forestlands in favorable geographies with manageable incidence rates of storms, drought, and fire. Weyerhaeuser's lands in western Washington and Oregon, for example, have a much lower risk of fire than land in the eastern parts of the states.

Weyerhaeuser plants forest lands with tree species and varieties that are best able to withstand regional extremes in climate that can occur over multi-decade growth periods. Maintaining a diversity of species helps the forest regenerate under changing climate conditions. Through Weyerhaeuser's tree improvement program, the company is developing tree varieties with genetic characteristics that will, for example, allow seedlings to withstand summers with slightly less water. In 2011, Weyerhaeuser spent $21.5 million on forestry research conducted by its in-house scientists, at universities, and at other research organizations on issues such as forest health and productivity, water quality, landscape management, and biodiversity.

The risk of pest outbreaks is actively managed through thinning and pruning practices. Logging and replanting schedules are also adjusted to account for weather-induced conditions that could delay those activities.[6] When severe storms occur, the company knows how to salvage timber, replant quickly, and work with affected communities. After the series of storms in Oregon and Washington in 2007, Weyerhaeuser and the Washington Department of Natural Resources reached a voluntary agreement to apply additional protections to two watersheds. Weyerhaeuser undertook a study analyzing the likelihood of future landslides under scenarios of increasing frequency and magnitude of storms, and committed to supplementing its existing risk assessment requirements with additional tools to predict landslides and protect landslide-prone slopes.

The five homebuilding subsidiaries of the Weyerhaeuser Real Estate Company (WRECO) have also begun to integrate local climate change considerations and green building principles into their businesses, for example in water-stressed regions of southern California and southern Nevada. WRECO's LivingSmart® program is offered on all new homes built, providing a combination of features that save energy, conserve resources, improve air and water quality, and minimize water consumption.[7] WRECO's Pardee Homes, the creator of the LivingSmart brand, uses revegetation and restoration techniques, wetlands protection measures, and water saving and native plant material designs for local climates.

Business Opportunities: Weyerhaeuser Solutions

Weyerhaeuser's corporate climate change strategy has also helped the company to think differently about its core products and new market opportunities (**Box 2**). Weyerhaeuser Solutions, established in 2011 as a wholly owned subsidiary, has begun to leverage Weyerhaeuser's long experience with land management to help others with interests in large-scale land holdings, industries and sectors such as energy, chemicals, materials and mining, agriculture, manufacturing, and government.[8] Weyerhaeuser Solutions helps clients, for example, to reduce their carbon footprints, source bio-energy feedstocks, and manage landscapes for optimal water supply and quality.

The idea for Weyerhaeuser Solutions first emerged from conversations with businesses about sustainability challenges, climate change, and increased interest in implementing sustainable forestry practices on company-owned land or investing in sustainable forestry projects. Weyerhaeuser Solutions is able to leverage its sustainable forestry expertise, technologies, modeling tools, and logistics capabilities to offer land management services at the vast scale required for global industries over large areas. Deploying Weyerhaeuser Solutions required a significant shift for the company, as it began sharing aspects of and developing marketable services from what had been considered confidential and proprietary information about sustainable land management practices.

CHALLENGES AND BARRIERS

It is impossible for Weyerhaeuser to predict precisely how changes in climate and weather will play out over the 30-year lives of trees. This uncertainty presents risks when decisions need to be made today that have long-term impacts on the business. Weyerhaeuser has traditionally managed that risk by closely monitoring and incrementally adjusting its timberlands management practices, continually updating models to reflect

Box 2: Business Model Innovation

In addition to annual strategy updates and planning, Weyerhaeuser conducts periodic company-wide direction-setting sessions to consider the impact of alternative scenarios on the business and to develop a robust response. According to Shari Brown, the company's director of environment and sustainability: "We always have to adapt and evolve. Nobody stands still. Market conditions change. Business conditions change. Climate changes." Through this process Weyerhaeuser has refined its high-level vision to provide "superior sustainable solutions to the world." The company recognizes that forest resources will increase in importance in the future as a critical source of materials, shelter, and energy, and each of its businesses is creating products and services to meet this vision. The timberlands business is expanding its scope to embrace the Weyerhaeuser Solutions model. The cellulose fibers business is generating a stream of new products to provide feedstocks for textiles, replacements for asbestos, and fuel-saving lightweighting additives for automotive plastics. The wood products business is expanding the amenability of wood as a construction material by introducing a fire resistant floor joist and thermally efficient structural components as well as creating bracing components for high wind regions.[9] On the horizon are developments through partnerships to produce transportation fuels from forest resources. Weyerhaeuser has a 50–50 joint venture with Chevron (Catchlight Energy) that combines Weyerhaeuser's expertise in land stewardship, resource management, and capacity to deliver sustainable cellulose-based feedstocks at scale with Chevron's technology capabilities in molecular conversion, product engineering, advanced fuel manufacturing and fuels distribution. Weyerhaeuser also participates in the Northwest Advanced Renewables Alliance consortium, led by Washington State University, to produce jet biofuel from woody feedstocks in the Pacific Northwest.

events on the ground in order to create a robust picture of current and future risks to forests and trees. The current challenge is to develop practices and actions that respond to an even wider range of possible outcomes over the long term. Moreover, current models that rely on historical climate and weather variability may underestimate the likelihood or severity of future changes.

For its manufacturing facilities, Weyerhaeuser does not currently conduct forecasting exercises to assess potential damages to mills or other operations from physical climate change. Weather risks to facilities—such as from wind and floods—are assessed by the company's property insurance carrier and are addressed through the company's strategies that ensure continuity of operations and effective responses to natural disasters, but they do not consider increased risks due specifically to climate change. In some cases, the company's sustainability strategies will help to mitigate some of these physical risks. For example, disruptions to energy supplies for manufacturing operations are mitigated by Weyerhaeuser's low-carbon energy independence: the company meets over 75 percent of its own energy needs with biomass sourced from its own plants.[10]

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The Center for Climate and Energy Solutions (C2ES) is an independent non-profit, non-partisan organization promoting strong policy and action to address the twin challenges of energy and climate change. Launched in 2011, C2ES is the successor to the Pew Center on Global Climate Change.

2101 Wilson Blvd., Suite 550
Arlington, VA 22201
P: 703-516-4146
F: 703-516-9551

WWW.C2ES.ORG