

Climate Risk and Financial Institutions

CHALLENGES AND OPPORTUNITIES



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The authors wish to extend special thanks to IFC investment, industry, environmental and social specialists, who have provided significant inputs to this document. Udayan Wagle (Director, Business Risk) is thanked for providing strategic direction. Samuel Dzotefe (Senior Investment Officer), Graham Smith (Manager), and Jan Mumenthaler (Head) are thanked for their detailed and helpful comments during the elaboration of the document.

This work benefited from support provided by the Trust Fund for Environmentally & Socially Sustainable Development (TFESSD), made available by the governments of Finland and Norway.

Reviewers

We thank the following for their critical review and comments:
Maarten Van Aalst, Craig Davies,
Susan Holleran, Ajay Narayanan, Samantha
Putt del Pino, and Udayan Wagle

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FOREWORD

Climate change is set to have a dramatic economic impact. It is already altering the availability of and demand for resources, supply and demand for products and services, the performance of physical assets, and the need for innovation. Failure to consider climate change in investment strategies can undermine projected financial returns and affect the non-financial risk management of institutions, particularly on development, environmental, and social issues.

The challenges presented by climate change are magnified in emerging markets, where most future global economic growth will take place. In these economies, climate change is shaping strategies to increase access to energy, clean water, and other basic services for people who need them most.

As they channel investment, financial institutions have an opportunity and responsibility to take a leading role in mitigating and adapting to climate change. Institutions managing investments in long-term assets should consider the financial risks associated with climate change, as well as the opportunity to create value by working proactively with clients and stakeholders to manage the risks.

IFC is supporting the efforts of several development and commercial financial institutions to take steps in this direction. This publication is part of our work to help financial institutions analyze the risks associated with climate change. Initiatives such as IFC's Climate Risk Pilot Program are also producing case studies that assess various approaches to managing and adapting to climate change in the real sector.

As climate change adjusts the way we think and act to reduce poverty and secure sustainable economic growth, IFC is committed to helping financial institutions meet the challenge. Our goal is to provide critical information and tools for financial institutions and the private sector to make smart decisions in the face of climate change, helping to create a better and more prosperous future for us all.



Rachel Kyte
IFC Vice President
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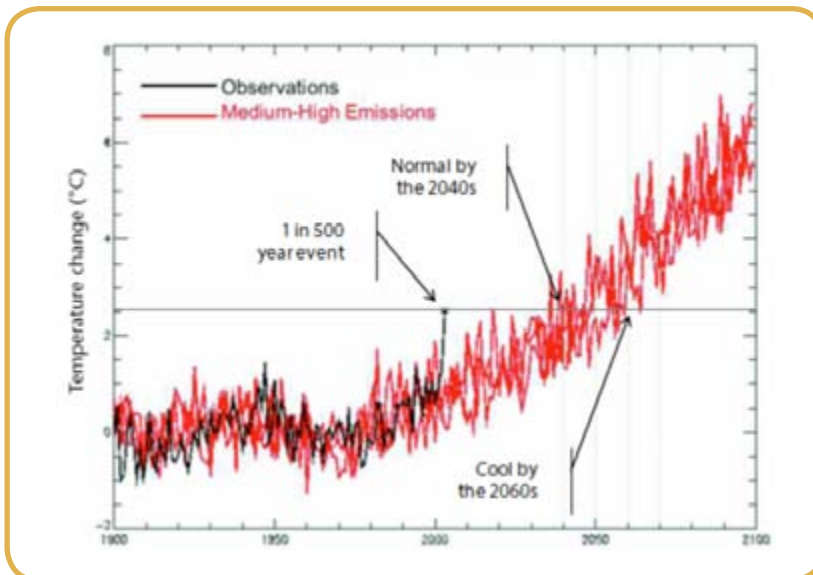
EXECUTIVE SUMMARY

MANAGING CLIMATE RISK IN THE FINANCIAL SECTOR

How significant are the impacts of man-made climate change today?

The summer 2003 European heat wave had disastrous consequences: water shortages shut down 14 nuclear plants at electricity producer EDF, causing electricity price spikes of 1,300 percent, which, because they could not be passed on to customers, resulted in a \$300 million loss; European agriculture lost an estimated \$15 billion; and more than 35,000 people died.

The ripple effects dramatically affected upstream and downstream sectors of various regions. France, the largest energy exporter in Europe, cut its energy exports by more than 50 percent. Output of animal fodder fell by up to 60 percent, and despite imports from countries not affected by the heat wave, such as Ukraine, livestock producers were affected by shortages and price hikes.



*Temperature Changes across Europe, 1900–2100 (Relative to Baseline Summer Temperatures in the Period 1961–90)
(Source: Stott et al, Hadley Centre and Oxford University)*

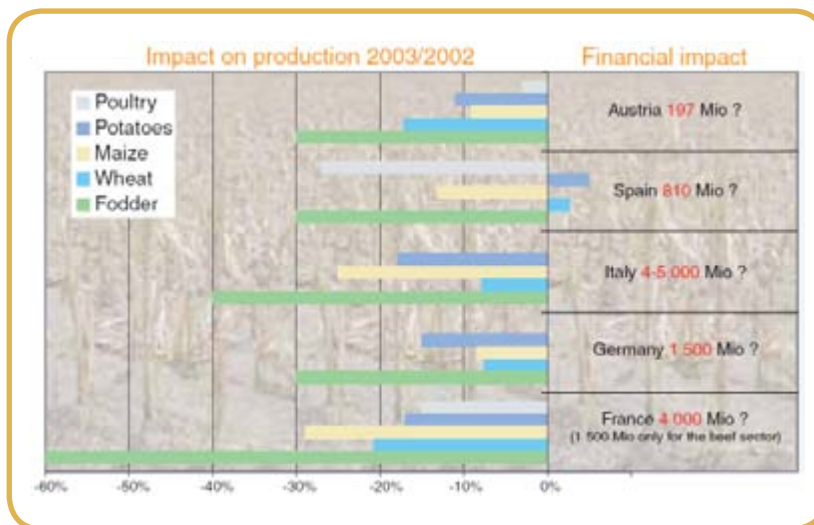
Without man-made climate change, a summer as hot as 2003 would have been an exceptional “1-in-1,000–year” event. Due to man’s influence on the climate, by 2003 the risk of such an event had already more than doubled to 1 in 500 years. By 2040 summers as hot as 2003 will be “normal,” 1-in-2-year events, and by 2060 they will be cooler than the average (COPA/COGECA 2004; Stott et al. 2004; UNEP 2004).

Do changing climate risks matter to short-term investments?

While short-term investments have shorter exposure, the risks are not completely eliminated. Extreme events, happening with increased frequency and intensity, can occur at any time. Furthermore, while extreme events and their effects on investments often grab the headlines, “creeping” changes in average conditions are already causing material changes in risk. For example, rising sea levels in some ports are reaching the crests of protective seawalls and quays built some decades ago. Added to this, the observed increased variability in wave heights and projected increases in the intensities of tropical cyclones further worsen risk profiles.

Clearly, not all investments will be affected by climate impacts, nor will they all be affected in the same ways. The severity of impacts will depend on several factors, including its climatic sensitivity, location, management practices, market conditions, existing policies and regulations, and so forth. However, it is likely that the impacts will have material effects on a significant number of investments over time.

Climate change related impacts that are material to investments’ performance are already occurring.



Impact of the 2003 European Summer Heat Wave and Drought on Agriculture in Five Countries (Source: Reprinted from UNEP 2004)

Some investment sectors are intrinsically more climatically sensitive, because of the nature of their operations or supply chains, such as those reliant on long-lived fixed assets or requiring large volumes of water. Others—notably agribusiness, energy, and tourism—operate in markets where supply, demand, and price fluctuate significantly in line with variations in the weather.

Investments in some countries or specific locations, such as those in water-stressed regions, or close to flood-prone rivers or coasts, are more exposed. Economic conditions also affect levels of vulnerability and the ability of economies to recover from climate shocks. Strong and diverse economies will be better placed to maintain the climate-resilient infrastructure and services on which businesses depend.

At the level of an individual business, management’s awareness and treatment of climate risk factors will be key determinants of business success. Proactive assessment and management will decrease the likelihood of adverse impacts from creeping changes or extreme events. Additionally, the first businesses to grasp new opportunities arising from changing conditions will be well positioned to gain competitive advantage.

Finally, knowledge about climate change and its impacts is evolving rapidly, and many of the key facts are now well established. Continuous advancement of information, supported by increased research and evidence, along with the application of risk-management tools, will facilitate incorporation of climate considerations into decision making. Overall, this should result in investments that are more climate resilient or better adapted to the changing conditions.

Proactive risk management will decrease the likelihood of adverse impacts.

RISKS TO PROJECT FINANCE AND REAL SECTOR INVESTMENTS

This report analyzes in some detail the risks to project finance and the performance of real-sector investments. Options, futures, derivatives, foreign exchange and more exotic instruments are not specifically addressed. However, real-sector investments are fundamental to economies, and many instruments are directly or indirectly linked to or influenced by them. As the systemic risks of climate change will affect whole economies, few instruments can be considered completely immune from potential impacts.

The unexpected volatility of conditions created by unaddressed climate impacts can affect projected results and weaken financial conditions. For general debt instruments such as loans, for example, debt-repayment capacity can be affected by the alteration of underlying cash-flow values—projected earnings and expenses—due to climate change, leading to deterioration of financial positions.

For equity investments, climate-driven deviations from expected results that affect an investment’s valuation are relevant for projecting returns on equity and planning exit strategies. Some equity investments will also be affected as analysts incorporate information about climate change impacts into their company valuations.



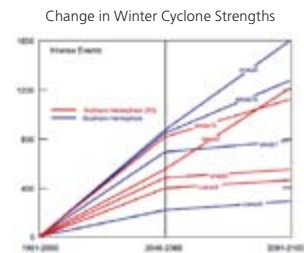
Financial performance and conditions for both equity and debt may be weakened by a number of factors:

- Market conditions, particularly supply and demand, can be a key determinant of future prices. Both supply and demand can be sensitive to climate factors. Future climate-driven changes in prices may, in turn, affect the competitiveness of investments.
- Efficiency, output, and performance of assets and equipment may decrease due to changing climate conditions, with consequences for revenue.
- Operating costs (OPEX) may increase due to changes in the price, availability, or quality of inputs. Maintenance costs may also increase.
- Insurance costs are likely to increase if climate-related claims continue to rise as projected. A more disquieting possibility, already a reality in some regions, is that insurance companies may completely abandon particular markets.
- Additional capital expenditure (CAPEX) may be required as a result of asset damage or decreased asset performance. Further, complying with environmental regulations may require additional CAPEX to upgrade facilities or equipment to cope with increased pollution risks.
- Staff health, safety, and productivity may be impacted by climate change, and this may lead to increased expenses.
- Loss contingency projections—reserves required to allow for potential disasters or other known risks—may need to increase as the risks of climate change become more likely and better quantified.
- Asset depreciation rates may increase. The rates currently used for accounting purposes generally reflect historical experience, but the effective depreciation rates of assets due to climate change may be considerably higher. Consequently, financial models may overestimate the real useful lives and value of physical assets. Faster capital depreciation could mean that assets need replacing more frequently, negatively affecting projected cash flows.

The 2007–8 droughts in Australia contributed to global wheat-price hikes of up to 85%. By 2030, up to 20% more drought months are projected over most of Australia.



The response of some insurance companies to increased weather impacts in the United States was cutting down the number of homeowner policies or complete pull-out from regional markets. Nearly 3 million U.S. households remained without homeowners coverage between 2003 and 2007.



Research in Alaska has shown that capital depreciation of transport, water, and sewage infrastructure could increase by 10–20 percent by 2030 due to climate change.

- Country risk may be aggravated by climate change impacts, particularly in economies where GDP is reliant on scarce water resources, or in smaller economies that are more vulnerable to catastrophic climate events. Significantly, studies show that rising temperatures in some regions are linked to increased risk of armed conflicts.



Floods and droughts in Kenya cost the country 16 % of GDP in 1998–2000. In 2001, drought-induced electricity rationing in Brazil led to economic losses of approximately \$20 billion, equivalent to 2% of GDP.

THE NEED FOR INSTITUTIONAL RESPONSES

Many financial institutions, including IFIs, members of the United Nations Environment Programme Finance Initiative (UNEP FI), and the Equator Banks, have environmental and social goals associated with their investments – as do the major companies in which they invest. If changing climate impacts are not taken into account, rates of noncompliance with environmental and social standards may increase. Using only historical data in environmental and social impact assessments is likely to disregard material changes that occur during a project’s lifecycle, and investments designed on the basis of such data may not be able to cope with new climate conditions.

As a result, mitigation measures in environmental and social management plans may not function as intended. For example, the Indian states of Rajasthan, Punjab, and Haryana have seen a net loss of more than 100 cubic kilometers of groundwater between 2002 and 2008, exacerbated by increased crop irrigation (Rodell, Velicogna, and Famiglietti 2009). Water-intensive industries in these and other water-stressed areas that fail to consider the interactions between climate change, water supply, and demand could put community livelihoods under greater pressure.

For institutions with a development mandate, failure to take climate change risks into account in investments may result in a deterioration of development performance, with all the components of development possibly affected: financial outcomes, economic, environmental, and social improvements, and overall public- or private-sector development. As recognized by the World Bank Group, “Left unmanaged, climate change will reverse development progress and compromise the well-being of current and future generations” (World Bank 2009b).

The objectives of institutional investors, such as pension funds, include creation of sustained revenues over a long period of time. Clearly, given this long-term perspective, institutional investors need to be particularly aware of growing risks to their investments in climatically sensitive sectors or regions. The size of investments and the need for diversification make many institutional investors *universal owners* whose success is dependent not on the performance of individual investments or sectors but on the long-term performance of the global economy. As already noted, unmitigated climate impacts may affect economies of whole countries and reflect negatively on the *universal portfolio*.

“Left unmanaged, climate change will reverse development progress and compromise the well-being of current and future generations.”

Some legal advisers are beginning to acknowledge that there is now sufficient information available on climate change for it to be taken into account in both strategic and operational decision making. This means that climate change may be close to attaining “legal significance” in court. Indeed, recent cases have demonstrated the willingness of courts and planning tribunals in Australia to accept evidence of climate change risks related to planning decisions. If climate change impacts are considered “reasonably foreseeable” by a court, decisions that do not take these impacts into account may incur liability in negligence. Further, some institutions may be falling short of information about climate their fiduciary duties if they fail to assess and manage climate risks, especially where long-term value creation is part of their mandate.

The increasing amount of information about climate change impacts is raising stakeholder expectations about institutional responses.

Reputational risks increase when there is a perception that an institution has fallen short of its stakeholders’ expectations. With the rapid evolution of evidence about the impacts of climate change, expectations are growing that these issues should be addressed. For example, a new investment that is heavily reliant on water resources, in a region where existing studies show future decreasing water availability, may face considerable scrutiny. If it cannot demonstrate that it will not adversely impact future water availability for local environments and communities, or for that matter future water availability for the investment’s adequate performance, the sponsors’ reputation may suffer, along with those of its investors. Even if the impacts occur only after investors have exited, reputation may be an issue if at the moment of investment there was sufficient information about potential risks and these were not addressed.



CONCLUSIONS AND NEXT STEPS

This report demonstrates that climate change and its impacts are likely to alter a number of conditions that are material to the objectives of financial institutions. If changing conditions are not actively managed, investments and institutions may underperform.

Most investments will be channeled through financial institutions. Given that the main effects of climate change are now well established, there is a considerable opportunity, as well as a responsibility, for these institutions to take a leading role in adaptation to climate change. Institutions managing investments in long-lived assets have both a direct financial risk to consider and the opportunity to create value by working proactively with their clients and other stakeholders to take steps to manage the risks.

Each institution has specific objectives and procedures, and so approaches to assessing and managing changing climate risks will vary. Many of the risks highlighted here may already be part of institutions' standard risk-management processes. Rather than creating new instruments for climate-related risks, the challenge for financial institutions and companies will be integrating investment-relevant information into existing procedures.

Several developmental and commercial financial institutions are already taking steps toward these goals. International Finance Corporation's Climate Risk Pilot Program has produced initial case studies that assess approaches to real-sector climate risk and adaptation, in addition to the present analysis of risks to financial institutions. Going forward, IFC will initiate the development of more general tools addressing climate risks and investments.

There is a considerable opportunity, as well as a responsibility, for financial institutions to take a leading role in adaptation to climate change.

NAVIGATING THIS REPORT



Climate Risks in the Context of Overall Risk Management

In making investments, institutions assume various kinds of risks, including credit risk, financial risk, strategic risk, and operational risk. If climate change is not considered, management of these risks may become more difficult, and the attainment of institutional goals may be impacted.

Part I of this report discusses these issues further. **Section 2** addresses credit risk as a component of investment appraisal and demonstrates how the credit and financial risks from a changing climate may be relevant to investment institutions. **Credit risk** is defined by many financial institutions as the potential reduction in value of on- and off-balance-sheet assets due to a deterioration in the credit profile of an institution's clients, the countries in which it invests, or a financial counterparty. Both investment and treasury activities are at risk of climate change–induced degradation in creditworthiness.

Financial risk relates to reduced liquidity available to meet an institution's obligations to disburse funds because of a loss in the value of its investments or other assets, its potential inability to access funding at a reasonable cost, and the deterioration in value of financial instruments because of market changes.

Section 3 analyzes how climate change may interact with an investment institution's **strategic risks**, which include the potential developmental, environmental, social and reputational consequences of failure to achieve its strategic mission and, in particular, sustainable development goals. The management of these risks is crucial to institutions' ability to brand themselves as trusted partners for future collaboration. Indeed, building enduring partnerships with emerging market players is another key strategic issue for investors and can particularly impact the ability of developmental financial institutions to achieve good development outcomes.

Section 4 discusses how climate change could affect institutions' operational risk. **Operational risk** includes the potential for loss resulting from events involving people, systems, and processes. These include both internal and external events.

Section 5 discusses the **legal risks** that may result from a financial institution's failure to manage adverse environmental or social impacts, or to meet its legal, fiduciary, or agency responsibilities.

Part II of this report reviews a range of cross-cutting risks that can affect the performance of many investment sectors. It also provides additional evidence on climate change risks for five climatically sensitive sectors: agribusiness, water, electric power, transport, and oil, gas, and mining.



Part I

Climate Risk and Financial Institutions

CREDIT AND FINANCIAL RISKS

Climate change will not necessarily affect the financial performance of all investments. However, it is likely that it will affect some, and certain investments may face significant risks.

The significance of the impacts of climate change on investment bottom lines depends on a combination of factors: the climatic sensitivity of the business (which depends on the nature of its operations), its location (which determines its exposure to climatic events), and the management practices it has in place. Additionally, there is a nonstatic, temporal dimension to climatic events. These elements in the context of a company's suppliers, partners, competitors, distributors, communities, and customers also determine the company's vulnerability to indirect risks.

By way of example, semiconductor companies consume large amounts of pure water. They are therefore sensitive to climate change impacts on water availability and quality, insofar as an interruption to water supply or a reduction in water quality would translate into revenue losses or increased operational costs (see **Section**). This sensitivity translates into a risk when such companies are located in areas where water is scarce and water runoff is projected to decrease. When appropriate risk management practices are in place, the costs of climate change can be significantly reduced.

Overview

- Investment institutions' credit and financial risk may be affected through a combination of direct and indirect impacts:
- Climate change will call into question the way institutions currently manage climate and weather risks.
- Changes in climate and their impacts on socioeconomic conditions will change some of the parameters and methods institutions use to develop financial projections and evaluate credit risks for their future investments.
- These climate change impacts have potential consequences for corporate financial and credit performance.

The report analyzes in more depth risks and effects on instruments related to project finance, and performance of real sector investments. However, similar implications will be applicable to a number of other financial instruments.

For **debt financing**, for example, a relevant factor for repayment is how projected annual variability in cash flow is correlated with climatic factors. Any long-term climate trends over an investment's lifetime will superimpose on preexisting variability, so that minimum and maximum cash flow values may change over time. For

example, understanding the correlation of seasonal rainfall and temperature with river flows and a hydropower plant's output may be important to determining the most appropriate debt structure and repayment schedule for that plant. Debt repayment could be structured according to years of most reliable and/or highest income and adjusted to years of less reliable and/or decreased income.

For **equity** investments, climate change trends over the investment lifetime that may result in changes in stock valuation may be most relevant for projecting returns on equity and planning exit strategies. Several features of equity investments suggest that they might, in general, be more exposed to climate risks than debt investments are:

- Equity repayment relies on the realization of an exit strategy and on the company's market value at that time. Since equity investments often have longer terms than debt, they are likely to be more affected as climate risks intensify. Awareness of climate risks is quickly growing among investors, and it will become increasingly difficult to exit successfully from investments that are not climate-resilient.
- Equity investors normally rank behind credit lenders in liquidation.

- Equity investments are intended to deliver a higher return overall, which strongly depends on management's quality and ability to create value. Generally, management capabilities around climate risks are currently very low.

Box 1. Examples of Business Sensitivity and Business Risk in the Context of Climate Change Impacts on Water and Energy

Many industry sectors have critical logistics or operations for which even a short-term disruption in water or energy supply creates significant losses and lower revenues. For example, semiconductor production requires large amounts of clean water to create and clean silicon wafers: to make a single 200 mm wafer, a typical semiconductor plant requires 7.5 m3 of ultrapure water.

It has been estimated for Intel and Texas Instruments that a shutdown of a factory or a delay in construction because of water unavailability or contamination could result in \$100–\$200 million in lost revenue during a quarter or a reduction in earnings per share of \$0.02–\$0.04, depending on which products were delayed. Semiconductor manufacturing companies in countries where climate change may reduce water availability or quality (e.g., China and Bulgaria) face additional business risks.

Significant costs as a result of power disruption can also occur for companies working in cement, steel and other metals, and glass, where shutdown can lead to losses in materials. For example, a shutdown of power in a steel refinery for more than a few hours can mean that the furnace has to be dynamited.

A further example of the costs of supply disruption relates to drought-induced electricity rationing in Brazil. In 2001, the rains did not come, and reservoir levels were at 30 percent of storage capacity. The effects of this drought, aggravated by decisions in the energy sector, meant that the government had to take severe measures to ration electricity. According to the U.S. Department of Energy, the government's aim was to reduce electricity consumption by 10–35 percent, based on the level of added value of the industry and the number of jobs affected. The usage reduction quotas affected some industry sectors more than others; those that did not comply were fined or eventually had their power supply cut off.

One group that was particularly affected was private electricity generation companies, such as AES Tiete, which has 10 hydropower plants in São Paulo State with a combined generating capacity of 2,650 MW. According to the director of AES Tiete, Mr. Barbosa da Silva, the company's assets were affected by the rationing. In 2000, AES Tiete Holdings had closed a \$300 million 15-year bond offering at 11.5 percent, but due to the rationing in 2001, the bond payment schedule had to be postponed. Though AES Tiete had cut costs dramatically in order to be able to pay dividends, the situation was too extreme. Since the company had insurance coverage from the U.S. Overseas Private Investment Corporation, it was able to negotiate a new payment schedule with the bondholders at the end of 2003.

The impact of Brazil's electricity rationing was national: it is estimated that the drought led to a loss of approximately \$20 billion, the equivalent of about 2 percent of Brazil's GDP. This is evidence of the potential impacts of climate change on investment country risk.

Sources: Klusewitz and McVeigh 2002; Morrison et al. 2009; Levinson, Klop, and Wellington 2008; Cashmore et al. 2006; UNEP Finance Initiative 2005

Because climate change may impact the credit profile of clients, it may have consequences for the returns of investment institutions' **structured products**. For example, partial credit guarantees (whereby an institution promises full and timely debt service repayment up to a predetermined amount, irrespective of the cause of default) agreed by an institution to the benefit of investments that are vulnerable to a climate-induced deterioration in their financial capacity may become less profitable as default probability increases throughout the lives of the guaranteed instruments.

When an institution agrees to a **risk-sharing facility**, it may incur increased and/or unpredicted credit risks for the pool of assets it guarantees in cases where the underlying client is in default as a result of unmanaged climate risks. For example, if the institution guarantees a bank portfolio of loans to farmers in an area severely affected by water scarcity, it may have to cover higher losses than expected because of increased rates of loan default to the lending bank as a consequence of decreased crop production.

Management of Present-Day Climate and Weather Risks in Investment Appraisal

Few investment institutions are incorporating consideration of present-day climate and weather risks into their investment appraisals, using historical data on climate trends and sector performance. Many types of investments have a strong intrinsic sensitivity to climatic conditions, including natural resource-based investments (e.g., in agribusiness or hydropower), as well as investments with industrial processes requiring water for processing, cooling, or steam generation (e.g., in mining and power-generation facilities). In those cases, the impact of past climate variability on performance is an element to consider at the investment appraisal stage.

However, in a changing climate, relying on historical climate data to make projections of financial performance is more likely to result in failure than using forward-looking estimates incorporating climate change projections. This is because the seasonality, intensity, and frequency of weather patterns is changing and will continue to change in the future.

Consequently, relying solely on backward-looking climate information to build financial and credit projections may be inadequate.

For example, agribusiness investments are often appraised on the basis of comparisons of observed weather records, climate trends, and geological and environmental conditions with crop suitability data. Agribusiness clients usually have observed weather data and understand the links between weather patterns and output. However, risk margins used to assess the sensitivity of financial projections for agribusiness investments may be inadequate to reflect climate change impacts, as they are often more concerned with unit production costs and how these compare to long-term average market prices. These prices are typically assessed using market data from the previous five years. Using such short records means that the influences of past climatic events, such as recurrent droughts, may not be picked up, even though these may have affected prices and the performance of past investments.

Financial and Credit Risk Analysis

At most investment institutions, proposed investments undergo a thorough appraisal that includes a financial and credit analysis based on assumptions about future investment performance and creditworthiness. The results of the joint financial and credit analysis are used to decide on pricing and to structure deals in the most optimal way. Financial and credit indicators are then monitored throughout the lifetime of the investment.

The set of established conditions and assumptions upon which financial projections are built aims to represent investments' performance throughout their lifetimes. Examples of how climate change may affect some of

the assumptions upon which financial analysis rests are numerous. The key areas of climate impact are:

- Market conditions and demand,
- Efficiency, output, and performance of assets and equipment,
- Operating costs,
- Maintenance costs,
- Insurance costs
- Costs to maintain staff health, safety, and productivity,
- Compensation for damage,
- Additional capital expenditure,
- Asset depreciation rates,
- Loss contingencies, and
- Country credit risk.

Each of these issues is briefly discussed in turn overleaf, illuminated by case studies.

Market conditions (or supply and demand) can be a key determinant of future prices. **Demand** can be sensitive to climate factors and the supply of certain commodities is vulnerable to climatic conditions (see **Box 2**). Future climate-related changes in short- and long-term average prices may, in turn, affect the competitiveness of investments.

Box 2. Market Risk and Opportunity: Impacts of Climate Change on Seasonal Energy Demand and Market Prices for Agricultural Commodities

While future energy demand and market prices for agricultural commodities are heavily influenced by socio-economic factors, they will also be affected by climate change. For energy, rising temperatures due to climate change will decrease winter heating demand and increase demand for cooling in summer. Extreme climate events can influence supply and demand for agricultural products, and hence commodity prices. Recent recurrent droughts have affected agricultural output in Australia, leading to increased world prices of key commodities.

Warmer winters are already having significant effects on the financial performance of oil and gas companies. Due to warm weather, for example, KeySpan Energy Delivery in the United States (now National Grid) reported a decrease of 19 percent in its natural gas sales in Massachusetts and New Hampshire between October 1 and December 30, 2006, compared to its forecasts. As a result, its net gas revenues were \$51.8 million lower in 2006 than in 2005.

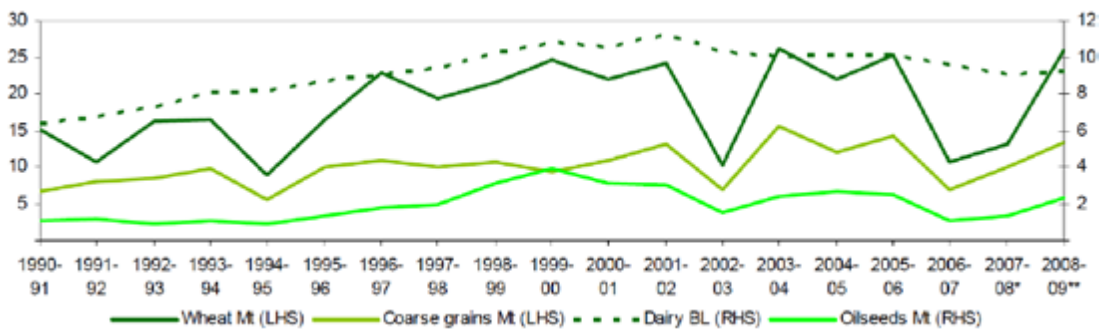
In Russia, it is estimated that a 2°C temperature increase will decrease fossil fuel demand by 5–10 percent and electricity demand by 1–3 percent. Winter heating demand in Hungary and Romania is expected to decrease in warmer winters by 6–8 percent by the period 2021–50. Worldwide, while demand for space cooling is currently lower than for space heating, it is growing rapidly in both high-income and emerging economies. Over the coming decades, research indicates that energy demand for residential air conditioning will increase most rapidly in South Asia, as the climate warms.

For agricultural commodities, the Organisation for Economic Co-operation and Development (OECD) and the Food and Agriculture Organization (FAO) noted that Australian droughts were a factor in the sharp commodity price spikes witnessed between 2006 and 2008. Various reasons have been put forward for the crisis, including the direct impacts of climate change on crop production which are considered to have made a ‘slight’ contribution.

The figure below shows Australian production of wheat, grains, dairy, and oilseeds showing how drought in the Australian wheat belt significantly reduced production in 2002–3, 2006–7, and 2007–8. According to the latest climate change projections for Australia, up to 20 percent more drought months are predicted over most of the country by 2030, so commodity price fluctuations will likely occur more often in the future.

Additionally, increased food prices driven by climatic factors may affect general price inflation, with food being a large component of the consumer price index (CPI) (an indicator of inflation) in many countries.

Australian production (Mt) of wheat, grains (left axis), dairy and oilseeds (right axis)



Sources: KeySpan Energy Delivery annual report, 2006; Kirkinen et al. 2005; Vajda et al, 2004; Islami 2009; Cartalis et al. 2001; Isaac and van Vuuren 2009; CSIRO and Australian Bureau of Meteorology 2007; OECD/FAO 2008; Gregory and Ingram 2009; Wight and Laffan 2008 (source of figure)

Efficiency, output, and performance of assets and equipment may decrease due to changing climate conditions, with

consequences for **revenue**. Output may change due to changes in long-term average conditions or because of increased incidence of extreme events,

such as droughts, tropical storms, and heat waves (see **Box 3**).

Box 3. Climate Change May Reduce Output of Hydropower Plants, Decrease Productivity and Output for Some Crops and Lead to Revenue Losses

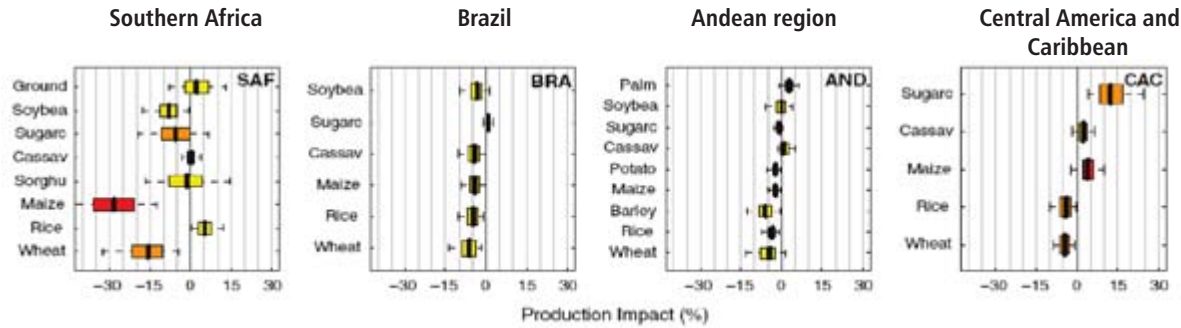
Reduced output from hydropower plants

Renewable energy investments are vulnerable to climate change, because the availability and reliability of renewable energy sources are a function of climate conditions. In Brazil, where hydroelectric power accounted for 83 percent of power generation in 2006, future changes in rainfall are anticipated to lead to decreases in river flows, affecting river basins. Recent research found that under certain greenhouse gas emissions scenarios, average annual flows in some rivers may decrease by more than 10 percent by 2035. As a consequence, it is estimated that average power production would decrease by up to 7.7 percent for the worst case (the São Francisco Basin). Across Brazil as a whole, guaranteed (“firm”) power output is projected to decrease by 1.6–3.2 percent.

Decreased crop productivity

In the near to medium term, the productivity of some crops is expected to be affected by climate change. For some crops, projections range from substantially negative to positive, depending on location (see figure below). The figure shows large ranges for the 25th and 75th percentile projections for some crops (shown by the colored bars) due to uncertainties about future precipitation changes. For other crops the range of projections is much smaller. In the longer term, the impacts of climate change on global crop productivity may significantly affect profitable agricultural investments. There will be different levels of agricultural output exposure: Russia, European and Central Asian countries, parts of China, and Argentina may present more favorable conditions for agricultural output in the future, whereas many countries in Africa, South America, and South Asia may see losses in agricultural output.

Probabilistic Projections of Production Impacts in 2030 from Climate Change (% of 1998–2002 average yields)



Note: Bars extend to the 25th and 75th percentile projections; the middle vertical line within each box represents the median projection. Dashed bars extend to the 5th and 95th percentile projections. Red, orange, and yellow symbolize ‘very important’, ‘important’, and ‘less important’ hunger importance rankings (HIR), respectively. The HIR categorise crops according to their share in the average calorie intake of a malnourished population (based on data from the FAO).

Performance losses for telecommunications companies in China

The most severe snowstorms in China in 50 years caused massive power blackouts in the winter of 2007/8, costing Chinese telecommunication providers at least \$152.8 billion in missed revenue during the firms’ peak business season. Operations at 24,000 telecommunications base stations were disrupted by the snowstorms, leading 14,000 of the stations to run on makeshift diesel generators to provide a basic service. The other 10,000 stations were completely shut down. In addition, 150,000 telephone poles collapsed and 16,000 kilometers of wires had been damaged by February 2008.

Sources: Pereira de Lucena et al. 2009; Lobell et al. 2008 (source of figure); Wai-yin Kwok 2008

Operating costs (OPEX) may increase due to changes in the price, availability, or quality of inputs (see **Box 4**).

Box 4. Operating Costs May Increase as a Result of Climate Change

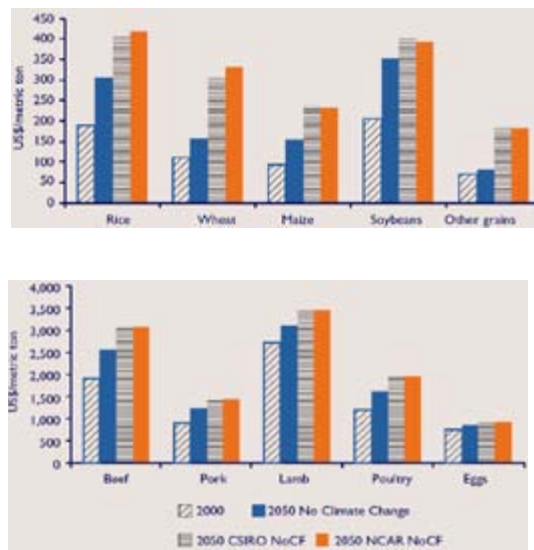
Increased operating costs due to power cuts in Ghana

Power cuts began in August 2006 in Ghana when low water levels were registered at Lake Volta, as the country relies on hydropower facilities for about 60 percent of its power. The Volta River Authority was forced to ration power supplies on a scale not seen since 1983. The crisis damaged the revenues of many of Ghana’s small and medium-size businesses. It also led to increases in operating costs for mining companies in Ghana and threatened mine closures. New mines had to be redesigned. As a result of energy disruptions, four mining companies collaborated to build a new 80 MW dual-fuel thermal power plant at an estimated cost of \$45.5 million to ensure energy security. While there is uncertainty about how rainfall in Ghana will change in the future due to climate change, rising temperatures are projected with high confidence. This will lead to more evaporation from Lake Volta and may increase risks of power shortages in the future, unless adaptation actions are undertaken.

Increased commodity prices

World prices for various crops and livestock are projected to rise due to climate change. This will result in increased input costs for agribusinesses, retailers, Fast Moving Consumer Goods (FMCG) companies, and farmers. The graphs below show world prices for various crops (top graph) and livestock (bottom graph) in 2000 and 2050. Three projected prices for 2050 are given: without climate change (blue bar); using the US National Centre for Atmospheric Research (NCAR) climate model (orange bar); and using the Australian Commonwealth Scientific and Industrial Research Organisation (CSIRO) climate model (horizontally-gridded bar) (excluding the effects of carbon fertilization (CF)). The 2050 ‘no climate change’ prices are higher than 2000 prices due to drivers such as population and income growth, and biofuel demand.

World prices of major grains and livestock products



Maintenance costs may increase as a result of climatic stresses (see **Box 5**).

Box 5. Increased Maintenance Costs for Railways

Heavy rainfall causing landslides in India

The profit and loss account of the newly built 760 kilometer Konkan Railway in India (KRCL) shows that 6 percent of the annual budget is spent on repair and maintenance. Out of the total repair and maintenance budget, close to 70% goes towards permanent ways, bridges and tunnels. According to the estimates of officials at KRCL, about 20% of this expenditure is used in addressing climate-related impacts, such as rain-induced landslides. This amounts to roughly \$1 million spent annually. Operations are suspended for an average of seven days each rainy season due to such damage. Future climate change, such as more extreme rainfall events, could increase expenditure on repair and maintenance activities.

Sea level rise increasing maintenance costs for primary rail line in the UK

A section of railway on the main line from London to Penzance in the UK is subject to temporary speed restrictions and repeated closures at Dawlish, due to its proximity to the sea. Sea level rise will result in more frequent 'overtopping' and make speed restrictions and line closures more frequent. There has already been an estimated 450mm rise in sea levels since the sea wall was built in the mid-nineteenth century.

Recent research assessing the sections of coast along which the train line runs indicated that the area was subject to an increase in the 1 in 100 year wave height of up to 9% in the 2020s, a corresponding increase in wave energy of up to 18%, and an increase in the 1 in 100 year wave height of up to 25% by the 2080s. As a result, disruptions from wave overtopping are projected to increase in the future, as shown below.

Projected percentage increase in future overtopping at Dawlish compared to 1961-90 baseline climate

Emissions Scenario (UKCIP02)	2020s	2050s	2080s
Low	120	796	5592
High	115	812	8067

The owner and operator of the rail lines, Network Rail, spends significant amounts of money to maintain the line from London to Penzance. It recently spent £9 million in engineering works, and a rapid response team is kept on constant guard. Maintenance for the most affected section at Dawlish currently runs at £500,000 year. With rising sea levels these costs can be expected to increase over time. Network Rail is planning to invest in moving the line all together in 2050.

Heavy rains damage transportation infrastructure in Tanzania

Flooding in the central Dodoma and Morogoro regions of Tanzania affected at least 28,000 people in late December 2009 and January 2010. In January, President Jakaya Kikwete said that two weeks of El Niño-related rains had caused damage to the central railway line and roads in the regions that would cost an estimated \$4.8 million to repair. This money would have to come from government funds previously allocated to development, meaning that the country's development plans would have to be postponed or abandoned, according to the president. The rainy season in Tanzania lasts until the end of May, meaning that additional flooding and diversion of government funds to emergency response could potentially continue for several months after this episode.

Sources: IIM 2003; RSB 2008; Mckie 2006 "Tanzania: Floods Affect 28,000 in Central Regions," January 21, 2010, allAfrica.com, <http://allafrica.com/stories/201001210613.html> (accessed March 24, 2010).

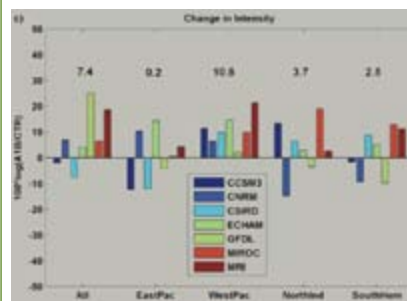
Insurance costs may also increase, and in some cases, insurance may become unavailable (see **Box 6**).

Box 6. Insurance Costs Rise in Hurricane-Prone Areas and Insurance May Become Unavailable in Future in Some Locations

Owners of oil rigs and offshore platforms in the Gulf of Mexico have been hit hard by increasingly scarce and expensive insurance coverage due to heavy asset damage by windstorms and hurricanes over the past few years. As a result, in 2009, many owners dropped coverage and began self-insuring, absorbing the risk of a high-impact hurricane season themselves. Major losses in 2008, especially from Hurricanes Ike and Gustav, significantly drove up prices for insurance coverage in 2009.

As sea surface temperatures (SST) increase due to climate change, asset owners will face a greater risk of more intense and more frequent hurricanes in the Gulf of Mexico. According to recent research, hurricane frequency is highly sensitive to increased SST: a 0.5°C increase in August–September SST in the North Atlantic (where hurricanes that hit the Gulf of Mexico originate) could lead to a 40 percent increase in frequency. Warmer seas also tend to lead to more intense hurricanes. This means that insurance prices could continue to rise, as more intense hurricanes generally wreak greater damage on assets (see figure).

**Change in Winter Cyclone Strengths:
Total Number of Events (left) and Number of Intense Events**



Source: Lambert, S.J., and J.C. Fyfe, (2006)

One way for insurers to limit their exposure to high risk areas is to completely abandon the market. This has already been observed in the Gulf region in the United States. In 2004, The US insurer Allstate stopped writing commercial insurance policies in Florida and decided not to renew 95,000 residential homeowner policies because of the four hurricanes that hit Florida in that year. The company has stated that climate change has prompted it to cancel or not renew policies in many Gulf Coast states, with recent hurricanes wiping out all of the profits it had garnered in 75 years of selling homeowners insurance.

In 2008, State Farm—Florida’s largest private insurer—stopped writing new policies in the state. This was after suspending sales of new commercial and homeowners policies in Mississippi the year before.

Sources: Emanuel et al. (figure); Environmental Defense 2007; Conley 2007; Garcia and Benn 2008; Mills et al. 2006

Staff health, safety, and productivity are likely to be impacted by climate change and this may lead to increased expenses (see **Box 7**).

Box 7. High Temperatures in Buildings and Reduced Worker Productivity

Although perceptions of temperature vary from individual to individual, most people begin to feel uncomfortable between 77°F (25°C) and 82°F (28°C). Research in the U.K., for example, considered that buildings which had reached a temperature of 28°C or above, for more than 1 percent of their occupied hours, had “overheated” (see table below). Higher temperatures can have consequences for workers’ morale and productivity and very extreme temperatures can result in potentially fatal heat stress.

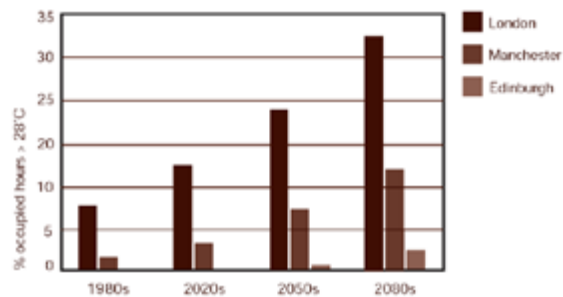
Temperature Thresholds in Buildings with Personnel

	“Warm” temperature threshold: 25°C (77°F)	“Hot” temperature threshold: 28°C (82°F)
Thresholds for thermal discomfort	Building has “overheated” if it is “hot” for more than 1% of occupied hours.	
Heat stress risk	Indoor temperature above 35°C (95°F) for healthy adults at 50% relative humidity.	

Note: Temperature thresholds for workers’ health and safety depend on air humidity.

Projections of higher temperatures due to climate change will translate into increased frequency of overheating. The figure below shows that in some U.K. locations, some kinds of office buildings already ‘overheat’, while in others, this will only be an issue many years from now.

Change in Percentage of Hours During Which 1960s Office Buildings Are Overheated Under a Changing Climate for Three Cities in the United Kingdom



Note: Temperatures are for middle floors in buildings. “Overheated” indicates that the threshold for “hot” temperature is exceeded.

Warmer temperatures and more frequent heat waves will lead to increased energy use for cooling, possibly offsetting decreases in space heating during colder months. Buildings that were not designed to cope with higher temperatures may need to be retrofitted to reduce cooling costs.

Sources: Shaw et al. 2007; (figure) Hacker et al. 2005

Compensation for damage may result in increased expenses because of climate change–induced incidents (see **Box 8.**) or legal fees to defend against climate change–induced tort or contractual claims.

Box 8. Class Action Launched by Australian Wildfire Survivors Against an Electricity Distribution Company

The largest class action in the history of the Australian state of Victoria commenced at the Supreme Court of Victoria in February 2009 against electricity distribution company SP AusNet and the Brumby government, in relation to a wildfire at Kilmore East, Victoria. During a period of extreme heat, high winds, and prolonged drought in southern Australia, a power line may have fallen and sparked a fire that caused serious damage to local communities and resulted in several fatalities.

SP AusNet is a wholly owned subsidiary of Singapore Power Limited and is responsible for maintaining most of the power transmission lines in Eastern Victoria. The class action focused on alleged negligence by SP AusNet in its management of the electricity infrastructure. The plaintiffs include thousands of farmers, as well as small business owners, tourism operators, and residents who lost their homes.

Immediately after the lawsuit was filed, SP AusNet shares dropped by more than 13 percent.

The Insurance Council of Australia estimated the cost of the bush fires at about \$A 500 million. SP AusNet’s legal liability is limited at \$A100 million under an agreement made by the former Kennett government with private utility operators, when the State Electricity Commission was privatized in 1995. As a result, the Brumby government could be legally obligated to pay damages amounting to hundreds of millions of dollars.

In addition to facing the class action, SP AusNet is dealing with damage to some of its electricity assets by the Victoria wildfire. “As a preliminary estimate, it is thought that damage has been sustained to approximately one per cent of SP AusNet’s electricity distribution network, mainly distribution poles, associated conductors and pole top transformers,” SP AusNet said in a statement to the Australian Securities Exchange.

According to the latest climate change projections for Australia, up to 20 percent more drought months are predicted over most of the country by 2030, and high temperatures will become much more common.

Source: Afrique en ligne 2009

Additional capital expenditure (CAPEX) may be required as a result of asset damage or decreased asset performance (see **Box 9**). Further, complying with environmental regulations may require additional CAPEX to upgrade facilities or equipment to cope with increased pollution risks.

Box 9. Additional CAPEX Expenditure for Transport Infrastructure due to Climate Change

Increased CAPEX to reduce the impact of permafrost thaw on the Tibetan Plateau

On the Tibetan Plateau, warming of the climate is already occurring, and the decreasing depth of frozen soils threatens the stability of the \$4.2 billion railway line connecting Lhasa, Tibet, to the Chinese network in Qinghai, China, known as the “highest” railway in the world.

The railway is built on “warm” permafrost (defined as being warmer than -1.5°C), with a mean annual ground temperature ranging from 0°C to -1°C . Monitoring confirmed that the soil under the rails is vulnerable: warm permafrost is very sensitive to disturbances from engineering activities, which have an immediate and direct impact on its warmth and moisture regimes.

Permafrost on the Tibetan Plateau has warmed by about 0.30°C over the past 30 years. Where human activity, such as the construction of the railway, has disturbed the soil the increase in temperature is double—about 0.60°C . The area of the Southern Qinghai–Tibet Highway with underlying permafrost decreased by 36 percent between 1974 and 1996, while the permafrost area of the Northern Qinghai–Tibet Highway decreased by 12 percent between 1975 and 2003. Research indicates that the permafrost area on the plateau may be reduced by up to about 60 percent by midcentury.

To manage the impacts of the changing climate, engineering techniques were used to stabilize the ground by keeping it frozen well below 0°C . At the design stage, the use of this cooling technique added costs representing 1 percent of total project expenditures. As the railway was built to withstand temperature increases of about 0.2°C and 2°C for soil and air, respectively, over the next 50 years, if the Intergovernmental Panel on Climate Change (IPCC) higher-end projections of around 2°C – 3°C increase in annual average air temperatures in the region by 2050 are realized, additional CAPEX may be needed to ensure that the railway can continue to operate.

Higher and more frequent peak temperatures may restrict air transportation, unless runways are lengthened

Air temperature and air humidity are among the factors used to calculate “density altitude” (the air density at a certain altitude). This measurement determines both aircraft combustion efficiency and the runway length needed for takeoff and landing.

Both air temperature and humidity will be affected by future climate change and are negatively correlated with air density. In the future, higher temperatures and potential increases in humidity will reduce air density and aircraft lift, requiring either longer runways at specified aircraft loads or a reduction of aircraft cargo. For example, a U.S. Department of Transportation report from 2008 states that “for aircrafts that use up to most of the pavement on even the longest runways, even a 1 or 2% increase in density altitude may put those aircraft out of commission for daytime operations on certain days.”

Adaptation to this climate change impact may include shifting flight schedules to early morning or evening, when the air is cooler, or making runways longer, with consequent CAPEX. However, retrofitting may not always be possible: in the case of airports constrained in size by their surrounding environment the CAPEX needed to adjust the length of runways to accommodate future climatic conditions may be prohibitive.

Sources: Cheng et al. 2008; Cheng 2005; UNEP 2007; Wu et al. 2007; Miao 2009; IPCC 2007; Karl et al. 2009; NRC 2008

Asset depreciation rates may increase. Although the rates currently used for accounting purposes may reflect historic experience, the effective depreciation of assets due to climate change may be considerably faster. Consequently, financial models may overestimate the real useful lives and value of physical assets (see **Box 10**). Faster capital depreciation could mean that assets need replacing more frequently, negatively affecting projected cash flows.

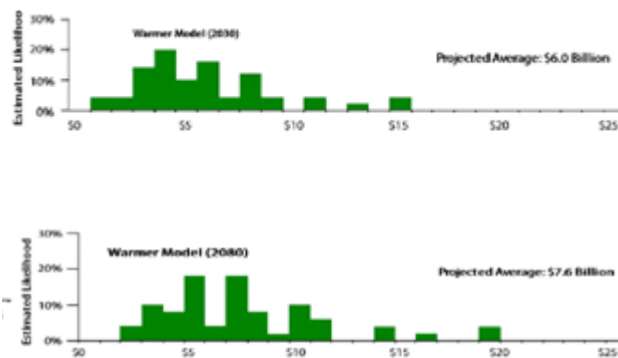
Box 10. Infrastructure and Assets Wear Out More Quickly and Require Additional Capital Expenditure under a Changing Climate

Wear and tear on assets and infrastructure will increase due to climate change. Research in Alaska has estimated the additional impact of climate change on capital depreciation for the state's infrastructure by calculating the baseline replacement costs for public infrastructure based on documented life spans of various asset classes and standard financial techniques for calculating depreciation, and applying annual engineering depreciation rates for percentage changes in temperature and precipitation, based on asset class, topography, and proximity to floodplains.

The study investigated two scenarios. In the first, adaptation is undertaken when climate change leads to a loss in useful asset life of 20 percent or more, with an additional associated cost of 5 percent, and allowing full asset life to be regained. Under the second scenario, without adaptation, public agencies simply react as climatic conditions change: they continue to design and construct infrastructure taking into account historical climatic conditions but not projected changes.

The study found that, under the "with adaptation" scenario, climate change will add \$3.6–\$6.1 billion (NPV, using a public sector discount rate of 2.85 percent per year) to the costs of wear and tear between 2006 and 2030, across a range of climate change projections. These figures equate to 9–15 percent of total asset value or a 10–20 percent increase in wear and tear costs (see figure below). Without adaptation, the costs of climate change are in the range \$3.6–\$7 billion between 2006 and 2030.

Range of Additional Infrastructure Costs for Alaskan Assets, Medium Scenario with Climate Change Adaptation, 2006-2030 (top) and 2006-2080 (bottom) (\$ billions, NPV)



Capital depreciation due to climate change is context-specific. In the case of infrastructure in Alaska, the main climate risks affecting wear and tear are thawing permafrost, increased flooding, and coastal erosion. In other parts of the world other climate risks will be relevant, such as droughts, wildfires, or snowstorms.

Source: Larsen et al. 2007

Table 1. Climate Change and the Credit Risk Analysis Process

Phases in the credit risk analysis process	Climate change risks	Examples of impacts on credit risk analysis
<ul style="list-style-type: none"> • Understanding the market and the project • Obtaining and verifying information 	<p>Market conditions may be influenced by a changing climate.</p> <p>Assessing an industry cycle and structure could include looking at the influence of climate change on industry competitiveness, growth prospects, and exports.</p> <p>For highly climate-sensitive investments, business performance indicators such as financial projections and asset valuations may not be accurate if not informed both by past and current climate conditions and by the projected effects of climate change.</p> <p>For highly climate-sensitive sectors or locations, the project sponsor’s experience in managing climate-related risks can be evaluated as part of their managerial and financial strengths and weaknesses.</p>	<ul style="list-style-type: none"> • Climate change may affect the comparative market performance of the company or project: production costs, sales, value, and growth of operating margins and net income may all change compared to competitors who have different vulnerabilities to climate, or who may or may not implement adaptation actions. • Failure to consider the impacts of climate conditions on output may lead to inefficient investment decisions: decreased output could limit internal cash generation and cause higher default probability in the case of overleveraged companies. • Evidence that management has considered the influence of ENSO on rainfall patterns and investment performance can be evidence of good management. On the other hand, a lack of industry experience in a management team can lead to the poor performance of an investment.
<ul style="list-style-type: none"> • Identifying critical investment risks • Performing credit risk analysis 	<p>Among investment risks, climate-change impacts may influence financial capitalization and liquidity risk, project completion risk, technical and operational risks, market risk, industry risk, and environmental and social risk.</p> <p>In a number of sectors and locations, and depending on the investment time frame considered, credit risk analysis may be significantly colored by climate change impacts:</p>	<ul style="list-style-type: none"> • EBRD is currently working on integrating climate change adaptation issues into its due diligence processes (Box 23). • Climate change—in particular, reduced rainfall—may have significant macroeconomic consequences for developing countries where a large portion of the economy is dependent on activities reliant on water resources. • Production could be at risk from decreased supply of energy or higher energy prices.

Table 1. Climate Change and the Credit Risk Analysis Process

Phases in the credit risk analysis process	Climate change risks	Examples of impacts on credit risk analysis
	<ul style="list-style-type: none"> • Country risk may be aggravated by climate change impacts on economic stability. • Financial ratios may be influenced by climate changes, which can lead to violation of loan covenants. • In cases where the investment relies on climate-sensitive inputs, estimates of the influence of climate change on the availability and prices of these inputs could affect assumptions in the production risk analysis. • Company environmental performance may be impacted, and additional OPEX or CAPEX may be required to achieve compliance. • Company social performance may also be affected. • Project economic performance and return to society may be reduced. • Capital adequacy and financial capacity, which can be affected by climate change, are key components of analysis of a company or project's balance sheets and income statements. • For equity investments, climate change may be an important element of planning for an exit strategy, as it can partly determine the future growth of the company or project. 	<ul style="list-style-type: none"> • Noncompliance with environmental regulations can also result in different forms of liability (contractual, civil, or penal) for the project owner, which may adversely affect cash flow (due to costs incurred), income (due to decreased sales), or market capitalization (due to loss of reputation). • Climate change can affect resettlement costs—for instance, the project sponsor may incur extra costs in ensuring that resettled communities have access to sufficient water resources. • The extent to which an investment provides a net positive contribution to the national economy of a country (economic rate of return) may be influenced by climate impacts. For example, climate-induced impacts on supply and demand may affect the generation of tax revenues. In essence, the economic rate of return of investments under a changing climate depends on the adequacy of these investments to cope with new climate conditions and on their ability to increase the adaptive capacity of the communities that they influence or serve. A climate change-resilient investment may have a higher economic rate of return. • Changes in climate may affect project cash flows, asset values and the company's ability to access capital. • With regard to equity investments, early growth will not be as affected by a changing climate as will medium-term growth (ca. 10 years). Future changes in climate may have a positive influence on growth in some equities, particularly those where management foresees the risks and plans proactively for climate resilience. In other cases, the influence of climate

Table 1. Climate Change and the Credit Risk Analysis Process

Phases in the credit risk analysis process	Climate change risks	Examples of impacts on credit risk analysis
<ul style="list-style-type: none"> • Developing financial projections • Assessing cash flow sensitivity • Analyzing key ratios • Evaluating the investment 	<p>The financial models developed by financial officers to forecast companies' ability to service debt and/or generate added value may be flawed if they do not consider the financial consequences of future climate conditions.</p>	<p>The following financial ratios may be impacted by climate change:</p> <ul style="list-style-type: none"> • The debt service coverage ratio may decrease as project internal cash flows are affected. • The measure of current ratio may be flawed, as some assets may be overvalued, not accurately representing the company's or project's value at liquidation. • The financial internal rate of return may decrease as projections of future cash flows are reduced because of climate-induced OPEX, CAPEX, or revenue loss. • In the case of equity investments, profitability ratios estimating future return on equity may be affected, if the amount of interim payments received (dividends) and, more importantly, the company's long-term market value is decreased because of changes in company income. • The discount rates used in cash flow calculations may be flawed if they do not reflect the impacts of climate change on country and investment risk. • Sensitivity analyses of the best- and worst-case future discounted cash flows may not be fully exploring the range of risks and uncertainties regarding company or project performance. The risk margins used may be flawed.
<ul style="list-style-type: none"> • Mitigating credit risk 	<p>Mitigating the risk that investee creditworthiness may deteriorate during the investment lifetime involves taking appropriate measures according to the risks identified and their probabilities of occurrence.</p> <p>Investors' mitigation measures may be insufficient if they do not identify such risks and probabilities in the light of climate change.</p>	<ul style="list-style-type: none"> • Covenants based on balance sheets, profitability, or cash flow may be set incorrectly, as the risk of default may be higher than anticipated. • The terms of the debt may be set incorrectly, as cash flows may not be able to match required repayments, particularly for longer-term loans. • Asset value at liquidation may be reduced, and costs of maintaining repossessed assets (land, property, or equipment) may increase.

Table 1. Climate Change and the Credit Risk Analysis Process

Phases in the credit risk analysis process	Climate change risks	Examples of impacts on credit risk analysis
		<ul style="list-style-type: none"> • The client's ability to refinance may be compromised once awareness of climate risks has increased, whereupon the client could become less attractive to future investors, making it more difficult for a current investor to exit. Other sources of repayment may also be affected: income from the sale of assets or equity by clients may be diminished as climate change affects market values. • The cost of insurance for clients may increase, and exclusion clauses may become more onerous. In some locations, or for some risks, cover may cease to be available. As a result, some companies may self-insure, which would require them to make financial provisions to cover future losses, affecting their financial capacity. It should be noted, of course, that insurance does not protect against gradual erosion in performance caused by incremental changes in average climate conditions.

Loss contingencies may need to increase as the risks of climate change increase and are better quantified. Loss contingencies typically cover risks that can be exacerbated by climate change, such as loss of or damage to property or assets from fire or other hazards, or from pending or threatened litigation.^c They are accrued on clients' income statements for probable losses for which the amount of loss may be reasonably estimated.^d Other climate-related risks that may fall within the scope of loss contingencies include increased risks of pest and disease outbreaks and of damaging droughts (see **Box 11**). It is possible that in the future some of these losses may not be insurable.

^c See IAS (International Accounting Standard) 37, "Provisions, Contingent Liabilities and Contingent Assets," <http://www.iasplus.com/standard/ias37.htm> (accessed July 29, 2009).

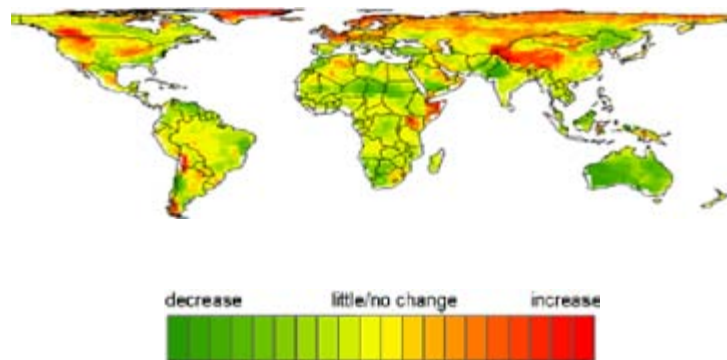
^d Loss contingencies are recorded as footnotes in the balance sheet. Losses that are probable or have a reasonable possibility of occurring should be disclosed in financial statements, indicating the nature of the liability and an estimate or range of possible loss. "Probable" means "more likely than not," or having a greater than 50 percent chance of occurring. A "reasonable possibility" of occurring means "more than a remote chance but less than 50 percent." Only remote liabilities do not deserve mention in financial statements. "Remote" means the chance of occurrence is "slight."

Box 11. Accounting for the Increased Risks of Fire and Pests and Diseases in Forest and Plantation Asset Values

Accounting for fire risk in valuing forest plantations

According to its annual report, a forestry plantation in East Africa has a biological asset valuation model that calculates fair value assuming that 8 percent of the plantation is destroyed by fire every third year. Due to changes in fire risk brought about by climate change, such assumptions may prove inaccurate in a few years' time, and future income projections for forestry investments based on these assumptions may be flawed. Recent research provides estimates of changes in the areas most prone to fire as a result of climate change, based on the IPCC A2 greenhouse gas emissions scenario (see figure).

Projected Changes in the Distribution of Fire-Prone Regions by the 2020s



Forest plantation asset value at risk from pests and diseases

Mountain pine beetle (MPB) infestations have been made worse by the effects of climate change. In 2007, MPB infestations were recorded in 9.2 million hectares of pine forests, and they destroyed millions of pine trees in British Columbia, Canada. In recent years, hotter and drier summers in conjunction with milder winters, have led to the largest MPB outbreak in recorded history. The range of the MPB is currently expanding northward and eastward into new habitats. Modeling has indicated that favorable climatic conditions have recently increased the area of optimal MPB habitat by more than 75 percent. Anecdotal evidence suggests that a pine beetle infestation generally reduces the value of a private woodlot or ranch by about 20 percent. Further, beetle outbreaks also create major fire hazards by clearing large portions of forest. This risk is further increased as Southeast Canada may also be prone to increased fire risk as a result of climate change (see figure above).

Sources: Herbohn and Herbohn 2006; Krawchuk et al. 2009 (figure); Walker and Sydneysmith 2008; Carroll et al. 2003

Country credit risk may be affected as there are several important correlations between climatic events and key factors that affect country credit risk. Climate change will influence the incidence and severity of these events in many countries, and so it may also influence their credit risk (see **Box 12**).

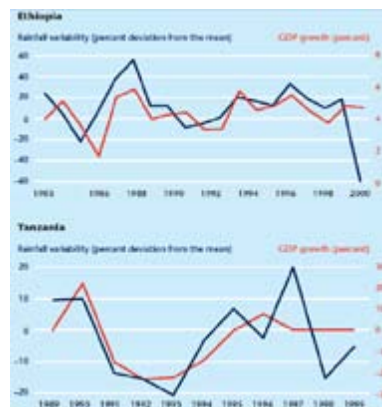
Box 12. The Compound Impacts of Climate Change on Country Credit Risk

Gross domestic product

According to Lord Nicholas Stern, author of the 'Stern Review on the Economics of Climate Change: The Stern Report' under business as usual scenarios the impacts of climate change could cost between 5-20% of global GDP every year, 'now and forever', without adaptation and mitigation.

In countries where agriculture makes a large contribution to GDP, such as Ethiopia and Tanzania, there can be clear relationships between climate variability and economic performance (see the figure below showing GDP growth following rainfall variability in Ethiopia and Tanzania).

Due to climate change the effects of rising temperatures are projected to lead to decreases in water runoff in western Ethiopia, which may affect agricultural production, though runoff in other parts of the country and in Tanzania is projected to increase.



In Kenya, floods and droughts brought about by El Niño and La Niña cost the country 16 percent of its GDP in the period 1998–2000. The 1997–1998 El Niño flood, for example, cost \$777 million in damage to transport infrastructure. In 2009, Kenya was hit again by mass hunger, water shortages, and power shortages (from hydropower production) as a result of a prolonged drought, and industrial production was reduced by \$1,400 million.

In general, developing countries and smaller economies face much larger output declines following a natural disaster than do developed countries or larger economies, and they will be

more vulnerable to climate change. These countries are less able to withstand the initial shock from a disaster and to prevent further spillovers into the macro economy.

Geo-political risks

Climate change may have implications for political stability, conflict and human security. Some regions are likely to be more affected than others due to their existing geo-political and socio-economic vulnerabilities. A UNEP assessment of Sudan, for instance, indicates that among the root causes of the Darfur conflict are land degradation because of desertification and the spread of deserts southwards. Average precipitation in Sudan has declined approximately 40 percent since the early 1980s.

The Secretary-General of the United Nations, Ban Ki Moon stated that “amid the diverse social and political causes, the Darfur conflict began as an ecological crisis, arising at least in part from climate change”.

A recent study has found that on average, warmer years lead to significant increases in the likelihood of war in Sub-Saharan Africa. When combined with climate model projections of future temperature, this historical correlation between temperature and civil war suggest a 54% increase in armed conflict incidence by 2030 or an additional 393,000 battle deaths, if future wars are as deadly as recent ones.

Sources: Jopson 2009; Noy 2009; McDonnell 2008; Van Aalst et al. 2007; Huang and Ren 2008; Desjardins 2008; Burke et al. 2009; UNEP 2007; Ban Ki Moon 2007.

STEPS IN THE FINANCIAL AND CREDIT RISK ANALYSIS PROCESS

Failure to consider the impacts of a changing climate outlined above could mean that investors' credit risk analysis processes are not robust, as climate change may lead to a decrease in the creditworthiness of certain investments. Most financial institutions' approaches to credit analysis for debt, equity, and guarantees have many aspects in common. The ways that climate change risks are relevant to phases in a typical credit risk analysis process are outlined in **Table 1**.

Corporate Disclosure and Investment-Risk Management

It is clear that unmanaged climate risks could feed through into the three key financial statements of investee companies: income statements, balance sheets, and cash-flow statements. At a company level, the aggregation of climate risks may result in decreased capacity to repay debt. Globally, concerns over climate risks to companies' financial performance are beginning to drive changes in regulatory requirements for improved corporate disclosure:

- In 2009, the U.S. National Association of Insurance Commissioners adopted a mandatory requirement that insurance companies over a certain size disclose to their state regulators the financial risks they face from climate change, as well as the actions they are taking to respond to those risks (NAIC 2009).
- In January 2010, the U.S. Securities and Exchange Commission (SEC) issued new interpretative guidance on 'Disclosure Related to Business or Legal Developments Regarding Climate Change' to provide clarity and enhance consistency for public companies and their investors. This comes from the SEC's realization that climate risks may hold financial costs that are not adequately featured in companies' published statements (U.S. SEC, 2010).
- The U.K. Climate Change Act of 2008 gave statutory powers to the secretary of state to direct statutory undertakers of "critical infrastructure," such as utility companies, to produce reports on how their organizations are assessing and acting on the risks and opportunities of a changing climate. The secretary of state can also ask for a group of organizations to report together on climate change adaptation considerations related to a specific location or a particular sector.
- In January 2009, the Japanese Institute of Certified Public Accountants published a proposal requiring companies to disclose information related to the physical effects of climate change on financial performance.^e

^e <http://www.japanfs.org/en/pages/029237.html> (accessed September 10, 2009).

Investors can try to manage key investment risks by recommending that their clients carry a combination of insurance policies. When investments carry appropriate insurance coverage, most of the financial impacts of extreme climatic events should be minimized, though the implications of incremental changes in average climatic conditions are unlikely to be covered. However, a changing climate will affect the likelihood, nature, and/or severity of extreme weather events, which will change insurers' risk exposure and may trigger a review of policy conditions and/or price upon insurance renewal. In some locations, insurance premiums will increase significantly—for instance, as flood, drought, or hurricane risks increase (see **Box 6** above). The development of limitation clauses may also exclude coverage in case of adverse business impacts—such as business interruption—that result from unmanaged climate conditions. In locations or sectors where climate change will cause very high risks of damage, insurance may become unavailable. As a result, some companies may be forced to start self-insuring, which requires making financial provisions to cover future losses and which could affect their financial capacity.

Corporate Credit and Financial Risk

The risks to client financial performance described above could translate into corporate financial risks for investment institutions. It is difficult to predict precisely how significant the financial consequences of climate change for investors will be, and it is unlikely that climate change alone will affect the liquidity or financial capacity of an institution. However, it will add to preexisting financial stressors, and institutions may, as a result, suffer financial impacts.

The potential financial risks for investment and treasury activities are summarized below.

Default probability

Lenders might experience increased probability of client payment default. The proportion of impaired loans in an institution's portfolio may be increased by more client liquidity shortfalls. Further, institutions might face increased liabilities associated with the financial guarantees they provide to their clients.

As regards investors' balance sheets, capital reserves requirements may increase to cover higher on- and off-balance-sheet exposures. Additionally, high liquidity ratios might be more difficult to maintain in the future.

Return on Equity

As outlined earlier, for those investments where climate risks lead to decreased net income and reduced growth, the value of investors' equity holdings will be affected, and exit strategies may not be realized.

Where climate change leads to environmental damage from an investment or increased community conflict, the investor might suffer from a reduction in capital gains realized on equity sale because of the investment's poor reputation (see **Box 13**).

Value of Assets Used as Collateral

Collateral assets are an alternative repayment source for debt in the case of default, provided they are valuable and can be repossessed and disposed of reasonably quickly.

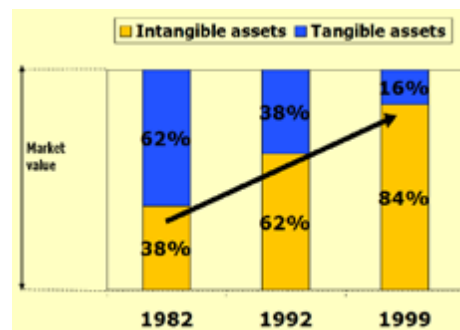
As information on climate risks and their financial consequences improves, it will become increasingly difficult to sell assets that are recognized to be at risk or that are difficult to insure against climate risks. This is true of property, land, and equipment held by lenders as security. For example, if real estate assets held as security are located in a flood-prone area, their value is likely to be reduced if floods become more frequent—as has already happened to property in the Florida Keys.

Box 13. Client Reputational Damage Linked to Climate Change May Result in Decreased Return on Equity

It is acknowledged that threats to reputation—whether real or perceived—can damage an image or brand. On the balance sheet, reputational value is considered an intangible asset and is accounted for under “goodwill” or “intellectual capital.”

More and more studies are demonstrating that reputation affects stock market values and contributes to explaining the difference between a company's market capitalization and book value. Some experts estimate that reputation can account for much of the 30–70 percent gap between the book value and market capitalization for publicly listed companies. The growth in the contribution over time of intangible assets to market value is shown in the figure below.

Development of the Value of Intangible Assets as a Percentage of Total Market Value of S&P 500 Companies, 1982–99



These issues present a growing risk for investors, particularly those with equity holdings in sectors highly exposed to reputational risks, such as mining. Furthermore, equity holdings in publicly listed companies may be at risk from reductions in company share prices associated with reputational losses due to climate-related environmental or social damage.

Sources: Tergesen 2002; Register and Larkin 2002; Daum 1999 (source of figure)

Overall Profit Margins

If an institution's investments underperform, its profit margins will be affected.

Climate change may also affect treasury activities. Institutions that hold liquid borrowings or liquid assets denominated in currencies other than U.S. dollars should note that there are links between weather events, commodity prices, and foreign exchange rates. For example, the 2008 snowstorm in China triggered increased imports and drove up prices of many commodities. This coincided with an increase in exchange rates of many currencies with the Chinese renminbi (McDonnell 2008).

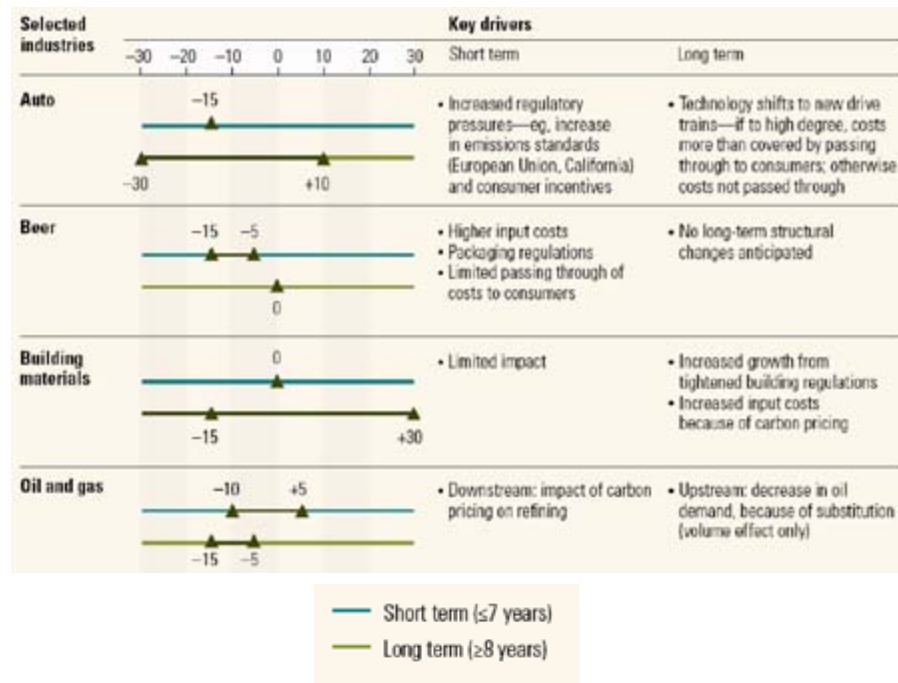
Contributions from investment institutions' equity portfolios remain the biggest uncertainty for operating income in the near term. In the recent past, the deterioration of operating income could largely be attributed to a downturn in income from equity investments. In the medium to long term, the performance of equity portfolios may be under pressure because of climate change.

Portfolio Risk Management and Performance

In those investment sectors or regions most vulnerable to the impacts of climate change, the performance of investment portfolios may be increasingly threatened. In the absence of a longer-term perspective on climate change risks, institutions' maximum country or sector risk exposure limits may become inadequate to protect profit margins.

Research by McKinsey has investigated how the drivers for carbon abatement could affect sector and company valuations (see **Figure 1**). As climate change adaptation leads to new or changed regulations, shifts in market demand, and calls for the development of climate-resilient assets and services, it may have similarly profound effects on the valuations of sectors and companies, with consequences for investors' portfolio performance. Mercer has partnered with a number of institutional asset owners and investment institutions to study asset allocation strategies in light of climate change (see **Box 14**).

Figure 1. Example of the Potential Impacts of Carbon Abatement Measures on Short- and Long-Term Company Valuation for Four Selected Sectors



Source: Brinkman, Hoffman, and Oppenheim 2008

Box 14. Study on Strategic Asset Allocation in Response to Climate Change

Mercer, a global consulting, outsourcing, and investment services firm, announced in March 2010 that together with 14 institutional asset owners and investors from around the world, the Carbon Trust, and IFC, it had recently launched a study exploring the potential impacts of climate change on asset allocation. According to a news release from Mercer, the study will identify potential new investment opportunities and possible future risks related to a variety of climate-change scenarios.

The research will explore volatility and correlations among asset classes, regions, and sectors under each scenario. Each study partner will receive its own tailored report assessing the effects on its asset mix. General findings will be made publicly available in the fourth quarter of 2010, with the intent of encouraging financial intermediaries, such as investment managers, consultants, and research firms, to develop tools, products, and services that facilitate appropriate responses to climate-risk scenarios. The report will also consider recommendations for policy makers and industry bodies.

The news release stated that financing arrangements would be crucial for mobilizing capital to help meet government targets to reduce emissions and to provide the funding required for adaptation to the physical impacts of climate change. Representatives from partner institutions were quoted as praising the study for helping to steer investors away from high-carbon investments and toward those that would succeed in a low-carbon business environment, and also for helping institutional investors fulfill their fiduciary duty to manage the financial impacts of climate change.

Source: Mercer 2010

STRATEGIC RISKS

Strategic risk is closely related to the achievement of an institution's mission objectives and often recognized as the most significant risk facing an entity, well above the financial risk (Brancato et al., 2006). Some of the common mission objectives, associated to a number of institutional investors and IFIs, include long-term value creation, and developmental, environmental, and social sustainability.

Changes in climate conditions will affect all of these categories and, if left unmanaged, imperil the achievement of these objectives.

Strategic risk is closely related to the achievement of an institution's mission objectives.

Changes in climate conditions will have consequences for developmental, environmental and social performance of investments. This may damage investors' development, environment and social credentials and, ultimately, their reputation.

In a changing climate, some investment sectors will carry more risk than others. Strategic risk management for investment institutions should take into account the implications of climate change for their portfolio risk exposure.

Long-term Performance

The objectives of institutional investors, such as pension funds, require creation of sustained revenues over a long period of time. IFIs are also concerned with long-term sustainable investment performance. Clearly, given this long-term perspective, institutional investors and IFIs need to be particularly aware of growing risks to their investments in climatically-sensitive sectors or regions. For example, a considerable portion of institutions' funds is allocated to real estate, as well as infrastructure. More than two thirds of the cities with population of 2.5 million or more are located in coastal zones, which are going to be affected

by rising sea levels and, in many cases, increased incidence of extreme events. Left unmanaged, the impacts will significantly affect these sectors, valuation of assets, and consequently investments. Additionally, the size of investments and the need for diversification make many institutional investors *universal owners*, whose success is dependent not only on the performance of an individual investment or sector but also on the long-term performance of the global economy. As shown in **Box 12**, unmitigated climate impacts may affect economies of whole countries, and reflect negatively on the *universal index*. At the global level, the cost of unaddressed climate impacts is estimated to between 5% and 20% of GDP per year.

Development

Investment Development Performance

Failure to take climate change risks into account is likely to result in a deterioration of the development results of the investments made by developmental financial institutions.

Development performance can be tracked throughout the project investment cycle:

- Prior to project approval, expected development impacts can be identified and indicators selected to capture expected results.
- As part of project supervision, development impacts can be monitored through the preselected indicators.

The overall development performance of an investment can be broken down into four components: financial, economic, environmental and social, and private sector development. Climate change is likely to affect all of these components. Performance on each of these components can be monitored using indicators that cover common themes for all developmental investments, spanning issues such as financial outcomes (financial rate of return or return on investment capital), economic benefits (e.g., economic return on invested capital, number of permanent jobs created, or value of taxes and other payments to government), environmental and social improvements (e.g., number of people resettled or percentage of pollution abated), and corporate governance and market benefits (e.g., improvements in transparency and disclosure). These indicators can also be tailored to track those outcomes only relevant to a particular industry (e.g., number of students enrolled or households with electricity).

The impacts of climate change on development are already widely recognized (see **Box 15**) and are expected to make it more difficult to achieve the Millennium Development Goals (MDGs). In particular, project underperformance due to unmanaged climate risks may put these goals at risk.

If unmanaged, climate change impacts are likely to affect the development outcomes of projects in the following respects:

- Development projections (done as part of investment appraisals) that do not take climate change impacts into account may be incorrect.
- Actual development outcomes may be affected because of the influence of changing climatic conditions on an investment and on its surrounding environment and stakeholders.

In both cases, all four key components of development may be affected. Climate impacts on financial performance were described in detail in **Section 2**. The impacts on the other three components of development are considered below.

Box 15. Development Organizations Recognize the Impacts of Climate Change on Development

- "Left unmanaged, climate change will reverse development progress and compromise the well-being of current and future generations." (World Bank 2009b)
- A 2005 report by a group of development organizations (including the World Bank) acknowledged the impacts of climate change on poverty alleviation and development: "Climate change is superimposed on existing vulnerabilities. ... The macroeconomic costs of the impacts of climate change are highly uncertain, but very likely have the potential to threaten development in many countries." (AfDB et al. 2005)
- The African Development Bank (AfDB) recognizes the risks of a changing climate: "They threaten the AfDB's mission of achieving sustainable poverty alleviation and economic development in Africa, through impacts on regional member countries' economic performance. They also pose a direct threat to the AfDB's own investment portfolio." (Van Aalst, Hellmuth and Ponzi 2007)
- "Climate change does represent a changing climate for development." (Outline for the 2010 World Development Report [World Bank 2009b])
- The OECD recognizes that "in addition to natural climate variability, climate change is already affecting development." The OECD also states that climate change may make it more difficult to achieve high development outcomes by "jeopardiz[ing] development gains achieved and mak[ing] it more difficult to reach development objectives including those agreed [in] the Millennium Development Goals. Adapting to the impacts of climate change is therefore critical. It is not just an environmental issue but also affects the economic and social dimensions of sustainable development." (OECD 2009)
- The U.K. Department for International Development (DFID) acknowledges that "climate change poses an unprecedented threat to development ..., especially in poor countries where poverty will increase and development will go into reverse. ... The smallest difference in climate can mean the difference between sufficiency and famine, survival and death." (DFID 2008)

Economic Performance

Economic performance may be measured by appraising project impacts on the national and local economy and on affected stakeholders, and also by quantifying the associated costs and benefits of the investment to society (or economic rate of return). All project stakeholders are exposed to a changing climate, which may change their vulnerability and relationship with the project. **Table 2** provides examples of the potential economic impacts of climate change on various categories of stakeholders.

Table 2. Examples of Climate Change Impacts on Some Indicators of Economic Performance

Indicators of economic performance per category of stakeholder affected	Potential impacts of climate change
1. Employees <ul style="list-style-type: none"> • Number of permanent and temporary employees • Value of wages 	<ul style="list-style-type: none"> • Projects that underperform due to the pressures of climate change may have to lay off employees. Nonpermanent contractors may be most at risk.
2. Customers <ul style="list-style-type: none"> • Price for product • Number of customers, patients, or users serviced. For global financial market investments, this can be, e.g., the number of small and medium enterprises (SMEs) financed or the outstanding balance of the SME portfolio. • Quality of product and service 	<ul style="list-style-type: none"> • Climate change impacts on OPEX and CAPEX may result in product price increases. • The number of customers serviced by the investment may change if climate impacts lead to changes in output or customer demand. • Product quality may be affected by decreased availability and quality of inputs used in industrial processes (e.g., water, raw materials) or because the production process does not function properly due to climate change.
3. Suppliers <ul style="list-style-type: none"> • Value or volume of supply from local suppliers • Number of new suppliers engaged 	<ul style="list-style-type: none"> • Supply chains may be compromised if climate change affects local suppliers. Diversification to obtain supplies from elsewhere would result in decreased revenues for local markets. • Alternatively, if the investment’s financial performance declines, its purchases from local suppliers may decrease.
4. Government <ul style="list-style-type: none"> • Value of taxes and other payments to government 	<ul style="list-style-type: none"> • If projects’ financial performance is negatively affected by climate-related impacts, they will likely generate less tax revenue.

Environmental and Social Performance

Climate change presents significant potential risks to the environmental and social performance of investments.

The environmental and social component of development performance also measures a project’s contribution to community development, another factor that is likely to be affected by a changing climate. The goal of community development is additional to a project’s environmental and social impact management, as it aims to improve

the living conditions of communities, including displaced communities and indigenous peoples. **Table 3** shows examples of indicators of community development that are potentially vulnerable to climate risks.

Table 3. Examples of Climate Change Impacts on Some Indicators of Community Development

Indicators of community development	Potential impacts of climate change
Financing to underserved markets (number or value of loans)	<p>The scope of profitable activities for which loans are worth offering may be significantly reduced in certain regions or sectors because of climate change. For example, changes in crop yields may jeopardize the livelihood benefits of agribusiness investments.</p> <p>If the developmental financial institution does not encourage the resilience of these projects or investments in alternative, less vulnerable activities, its contribution to community development may be severely threatened.</p>
Community development outlay (in value)	<p>If climate change impacts are not considered, community development expenditure may go toward infrastructure or equipment that is not designed to cope with future climate conditions. Climate impacts may then reduce the useful lifetime of assets funded and thus reduce community development benefits.</p>
Contribution to local health (in value)	<p>In regions where climate change brings new diseases or creates additional health burdens, medical staff may not have adequate training or resources to treat patients appropriately, compromising the quality of health services provided. Community health programs (e.g., for malaria control) may need to be stepped up when disease prevalence increases if they are to deliver their intended benefits.</p>

A livelihoods approach to development provides a useful conceptual framework for examining the ways in which climate change may affect communities. It is used by many development institutions, including the United Nations Development Programme (UNDP), the U.K. Department for International Development (DFID) and Oxfam.

Considering DFID’s Sustainable Livelihood Framework, for example, the following climate change impacts on community development can be identified:

- Climate change will accentuate preexisting community vulnerabilities.** As discussed throughout this section, climate change will increase risks to land and natural resources that are already threatened by development, overuse, and pollution. Communities that rely on these resources will face threats to their existing way of life.
- Livelihood assets will be directly at risk from incremental and extreme climate change.** Climate change will affect financial capital, physical assets, human capital, and natural capital. These impacts will be especially critical in the case of basic infrastructure that is needed to support development, such as water supply and sanitation, energy, and transport infrastructure.
- Community livelihood strategies and outcomes will be affected.** Climate change will impact the livelihood strategies that community members engage in, including agriculture, education, fishing, and mining. The existence and profitability of these activities will be affected as climate change will change levels of expenditure, outputs, and sales.

- **Private companies' failures because of climate change will affect the number of livelihood strategies available to communities.**— Companies, including investment clients, can play a major role in the process of development by delivering essential services and products, purchasing from local suppliers, and trading with local partners. If these companies underperform due to increased climate stress and have fewer beneficial impacts on local and national development in the private sector, livelihood strategies may be at risk.

If climate risks are not incorporated into development institutions' investment models, climate-related degradation of community livelihoods may not be foreseen and managed appropriately, and therefore projects may underperform.

Private-sector Development

This component of development performance measures the market impacts of investments in businesses, using indicators such as increased competition, privatization, changes in law or regulation, improved quality of corporate governance, and new linkages with other firms or demonstrations of "good practice."

Table 4 shows some examples of how climate change may impact these development indicators.

As outlined in **Section 2**, businesses that are not climate-resilient may become less competitive over time and in the worse cases may fail altogether. Management of climate risks is increasingly seen as a measure of corporate governance and good practice, so companies that fail to manage them may not provide good examples for others to follow.

As a result, the positive effects of these companies may be called into question. Furthermore, opportunities to promote the market introduction and transfer of climate-resilient technologies or practices may not be identified by developmental investors' appraisal processes.

Table 4. Examples of Climate Change Impacts on Some Indicators of Private-Sector Development

Indicators of private-sector development	Potential impacts of climate change
Other institutions adopting investee company's practices	Investors may be supporting unsustainable business models by investing in projects that are likely to fail as a result of climate change. If these models are replicated by other businesses, they may lead to climate-vulnerable markets.
Receipt of international accreditation	As new legislation or regulation is introduced to encourage climate change adaptation, achieving external accreditation may become more difficult.
Introduction of risk management and credit risk scoring systems (for investments in global financial markets)	Those systems introduced to improve risk assessment and management that do not consider climate change may be flawed, especially in the case of nondiversified business portfolios centered on highly climate-dependent sectors and/or vulnerable locations.

Environmental and Social

Introduction

According to the Intergovernmental Panel on Climate Change's Fourth Assessment Report (IPCC WG 1 2007), climate change has already caused changes in environmental conditions, including physical and biological systems on which communities depend. Changes in climate conditions can seriously affect a project's environmental and social performance. For instance, in many locations water resources and quality are becoming increasingly stressed by higher temperatures and changes in rainfall patterns. At the same time, the needs of a project and of its local

environment and communities for water may increase due to climate change, leading to greater pressure on resources and potentially threatening their sustainability. Such risks may result in additional burdens and costs to investments.

Unless it is considered as a part of project planning and design, climate change will increasingly affect the environmental and social performance of projects and lead to increased risks of environmental damage and pollution from investments. In some cases, this will result in increased rates of noncompliance with local regulations, international standards, and investment institutions' own performance standards.

These concerns are being recognized and addressed internationally. For instance, the European Union white paper "Adapting to Climate Change" (CEC 2009) aims to ensure that climate change impacts are taken into account through implementation of its Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA) Directives. Similar initiatives are being undertaken by other banks (see **Box 24** below), national governments,^f and some companies (see **Box 16**).

^f Country signatories to the UNFCCC are required, at a minimum, to publish National Communications on climate change and, in the case of Least Developed Countries, National Adaptation Programs of Action describing urgent and immediate adaptation needs. Some countries have gone further and adopted legislation on climate change including adaptation requirements (e.g., the U.K. Climate Change Act of 2008).

Box 16. Approaches to Climate Risk Assessment and Management by BG Group

Policy statement

"We are assessing the impact on our operations of changes to environmental conditions linked to global warming, including assessments of the extent to which the design of major projects takes into account the IPCC's climate predictions. We also understand that climate change may directly affect the communities and ecology close to our operations. We will work with stakeholders to identify adaptation strategies and goals which provide mutual benefits. This may include examining options for social investment programmes to assist affected communities."

Operational response to climate change

"As part of our Environmental Expectations Standard we include mandatory requirements governing climate change adaptation which set out how we assess the risks to our operations from foreseeable environmental changes arising from climate change, together with our approach to risk mitigation.

We have designed a Climate Risk Management Framework to support our assets and projects in delivering against the Standard's requirements. This specifies the step-by-step procedure to follow, based on the BG Group Business Risk Management Process.

This is a new area of risk assessment for the Group, based on predictions that are uncertain and encompassing periods of time that can be measured in decades."

Source: BG Group Sustainability Report 2008, available at BG Group Web site, Online Reporting Centre, http://bgara.blacksunplc.com/sr/resource_centre.html (accessed May 5, 2010).

Principles Underlying Performance Standards

Routine approaches to undertaking environmental and social impact assessments (ESIAs) have been established in the last 10 to 20 years, often based on the assumption that the climate is static and drawing on historical observations of climatic and environmental conditions. As climate change intensifies, these assessments may become invalid and the social and environmental sustainability of projects may be reduced, along with their financial and economic performance. To ensure environmental and social sustainability and positive development

outcomes from projects, analysis and management of climate change impacts over the whole project lifetime should be included as part of site selection, project design, management, monitoring, and decommissioning.

In cases of environmental pollution caused by a facility, clients may be exposed to liabilities including the costs of remediation and compensation as well as damage to their reputation and community relations. This may require costly retrofitting during the lifetime of the facility. In many cases, climate change resilience can be built in at a lower cost at the planning and design stages.

The following sections discuss some examples of standards that investors and developmental financial institutions can use to measure the performance of their investments, with particular emphasis on climate risks. These examples are summarized in **Table 5**.

Table 5. Overview of Investment Performance Standards and Climate Change Risks

Performance standards	Examples of climate risks
Managing social and environmental performance throughout the life of a project	Environmental and social impact assessments may be flawed if climate impacts on ambient conditions, the project, and its environmental and social receptors, as well as the interactions between them, are not taken into account.
Protecting basic rights of workers and ensuring a sound worker-management relationship	Unmanaged climate impacts may exacerbate or create additional risks to workers' health and safety and working conditions.
Preventing and controlling pollution in line with internationally recognized technologies and practices	Clients may incur additional costs to comply with pollution standards as climate change interacts with environmental conditions and with the behavior of pollutants emitted by facilities.
Avoiding or minimizing the risks and impacts of the project on community health, safety, and security	Climate change may lead to increased or additional project impacts on communities.
Managing adverse impacts of land acquisition and involuntary resettlements	Climate change may impact ambient conditions and, therefore, the costs associated with providing sustainable areas of land and infrastructure for involuntary resettlement.
Avoiding or managing threats to biodiversity arising from operations as well as sustainably managing renewable natural resources	Impacts of climate change on biodiversity, natural resources, and habitats may affect existing practices and increase the costs of undertaking conservation and sustainable resource management.
Avoiding or managing adverse project impacts on indigenous peoples and creating opportunities for them to participate in, and benefit from, project-related activities and to play a role in sustainable development	Indigenous peoples may perceive projects as conflicting with their own needs for sustainable natural resources, particularly when climate change affects the availability of those resources.
Protecting cultural and natural heritage from the adverse impacts of project activities	Protection of cultural and natural heritage may be more difficult if project activities are impacted by climate change; extreme events such as heavy rainfall may lead to the migration of pollutants from project sites to culturally sensitive sites.

Social and Environmental Assessment and Management Systems

An ESIA may be incomplete if it does not take account of changing climatic and environmental conditions (see **Figure 2**). Using only historical data in ESIA is inappropriate, and projects designed on the basis of such data may not be able to cope with new climate conditions. This may mean that mitigation measures developed through ESIA and management plans do not function properly.

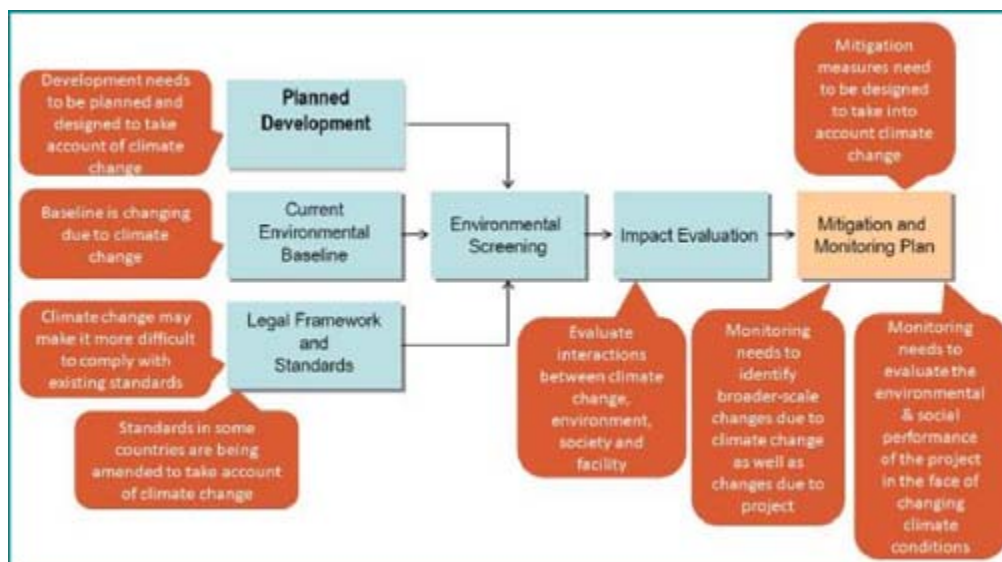
This issue is already recognized by the European Union. The white paper “Adapting to Climate Change” (CEC 2009) proposes a framework for action to include climate change in key EU policies. The European Commission

is working with member states and stakeholders, setting guidelines and exchanging good practices, to ensure that climate change impacts are taken into account when implementing the EIA and SEA Directives and spatial planning policies.

Typically, the aspects of the environment and society that might be significantly affected by a project and that are included in ESIA are communities, flora, fauna, soil, water, air, climate, landscape, and material assets, including items considered part of a society’s architectural and archaeological heritage. ESIA and management plans need to consider the characteristics of a project in combination with its proposed location in order to identify the potential for interactions between the project and its environment.

However, there is a two-way relationship between a project and its environment and local communities. A project can impact on the environment or communities (and ESIA aim to address this), but at the same time, the environment and communities can have an impact on the project. All three parties in this relationship may be affected by climate change. Consequently, the interactions between them may change too.

Figure 2. The Standard ESIA Process and Climate Risks



Source: Acclimatise, 2008

By way of example, changing climate conditions are leading to increased flood risks along coasts and rivers. This means that flood risks (and consequent business risks) to projects located in the vicinity of coasts and rivers are increasing. As discussed below in **Section**, a flooded site can result in pollution entering watercourses and wider environmental resources being damaged. Unless the mitigation measures in the ESIA for flood risk management on-site have taken account of these changing risks, they may fail to perform as intended over the project's lifetime. Similarly, climate change is expected to lead to increased rates of wetting and drying of soils and, on clay-based soils, increased risks of subsidence and heave. These changes in ground conditions may open up new pathways and pollutant linkages in the soil, so that ESIA mitigation measures to manage contamination risks could prove inappropriate unless these changes are considered (see **Box 17**).

Box 17. Biosecurity Breaches at Pirbright, U.K., Due to Poor Management and Heavy Rainfall

In September 2007 the U.K. Health and Safety Executive (HSE) published its report on biosecurity at the Pirbright Laboratories, which were at the center of a foot-and-mouth disease outbreak in August 2007. The HSE report showed that several factors were implicated in the outbreak, including the likelihood that wastewater containing the live foot-and-mouth virus in the laboratory's drainage pipes leaked out and contaminated the surrounding soil. This conclusion was supported by evidence of long-term damage and leakage, including cracked pipes and pipe work breached by tree roots. Excessive rainfall and localized flooding in July 2007 were thought to have increased the potential for virus release from the drain.

The biosecurity breaches at Pirbright demonstrate how a complex chain of events and control failures can lead to dangerous contamination and massive reputational damage for the organization found responsible. They reveal how vital it is that site monitoring and maintenance regimes and site management practices be reviewed in the light of climate change.

As climate change intensifies, heavy rainfall events are becoming more common. High water levels can lead to groundwater entering drainage systems through cracks and misalignments in pipe work. Any installation that deals with contaminated wastewater could potentially be affected in a similar way to Pirbright.

The likelihood of tree root damage is increasing due to climate change, as trees seek extra moisture from the soil during periods of extended drought. This points to the need for extra vigilance in monitoring and maintaining drainage systems. Further, site vegetation managers must carefully consider the size, species, and placement of trees in the light of climate change scenarios, to minimize damage to pipe work and subsidence risks, especially on shrink-swell soils.

This case study demonstrates that where there are poor environmental management practices, the impacts on the environment may be magnified due to climate change.

Source: HSE 2007

An effective social and environmental management system is one that is dynamic and continuously adapting. Monitoring of the environmental and social performance of a project should be adjusted according to performance experience and feedback in the face of a changing climate. For example, if site drainage systems are inadequate for the amount of runoff experienced, leading to flooding and off-site pollution, the project may need to closely monitor rainfall and its impacts to decide when the drainage system requires an upgrade.

Analysis of trends in observed climatic conditions, coupled with forecasts of future climatic conditions from global and regional climate models, provides a basis for climate-resilient project design. The IPCC and related initiatives have evaluated the best-performing climate models globally. Appropriate use of climate model output, taking account of uncertainties and levels of confidence in the various climate variables, can help in designing projects that are adaptable to the ranges of projected future changes (see **Box 18**).

Box 18. U.K. Government Guidance on Taking Account of Sea-Level Rise in Flood and Coastal Management

The U.K. Department for Environment, Food, and Rural Affairs (Defra) has provided regional sea level allowances to be used in designing flood and coastal management schemes. The allowances take account of climate change by incorporating the effects of global warming on the thermal expansion of the oceans and the melting of ice from land glaciers (using projections from the IPCC), as well as the effects of local land movements (subsidence and uplift) around the U.K. coastline. The Southeast of England, (where London is located) for example, is sinking, whereas Scotland and Northeast England are rising slightly. Therefore the sea level rise allowances for the Southeast are higher.

The allowances increase over time because the projected future rate of increase in sea level rise is non-linear. So, for instance, for Southeast England and London the allowance for the period up to 2025 is 4mm/yr, but from 2025-2055 this rises to 8.5mm/yr.

Because of high uncertainties, no allowance for climate change effects on tidal surge or waves is included.

Source: Defra, 2006

Labor and Working Conditions

Project developers should promote safe and healthy working conditions and the health of workers.

According to the IPCC (WGII 2007, p. 393), there is emerging evidence that climate change has already

- altered the distribution of some infectious disease vectors (a medium–confidence finding),
- altered the seasonal distribution of some allergenic pollens (high confidence), and
- increased heat wave–related deaths (medium confidence).

Climate change may therefore lead to a deterioration of working conditions in some locations due to incremental changes in temperature, rainfall, and humidity over the lifetime of the project. In addition, changing climatic conditions will result in changing disease patterns and the potential for increased risks to health and safety due to more frequent and intense extreme weather events. This may indicate the need for increased surveillance, better linkages with organizations that monitor diseases, and additional worker health and safety training (for further discussion, see **Section**).

Project developers should provide workers with a safe and healthy environment, taking into account the inherent risks of the project continuously throughout its lifetime. In addition, developers should take steps to prevent accidents, injury, and disease by minimizing the causes of the hazards, as far as is reasonably practicable, over the lifetime of the project.

Pollution Prevention and Abatement

Project developers should apply pollution prevention and control technologies and practices that will avoid or minimize adverse impacts on human health and the environment.

Achieving this goal may be difficult if climate change is not taken into consideration. Projects should be designed with consideration for existing ambient conditions and for existing and future land use, as well as for potential cumulative impacts on ecologically sensitive or protected areas. If future changes to ambient conditions are not assessed, then pollution management techniques selected at the planning and design stage may be inadequate in the future.

In particular, managing and reducing GHG emissions may become more challenging due to increasing energy demands for cooling, pointing to a strong need to emphasize energy efficiency practices and to use nonfossil fuels. Also, managing and minimizing pesticide use may be affected by the migration of new pests and invasive species into project locations.

In order to best manage changing climate risks, pollution prevention and control techniques should be applied throughout the project lifecycle. It is important to note that potential cumulative environmental impacts should be considered in light of the finite assimilative capacity of the environment.

In some countries, standards are already set to take into account seasonal changes in the environment, and some standards are being amended specifically to take climate change into account. For example, in the United Kingdom, the approach for discharge consents to water bodies is to set different limits on pollutant loads for summer and winter. These limits are based on seasonal changes in the flow, water quality, and temperature of

receiving bodies. In England and Wales, water abstraction consents granted since 2001 are “time limited” to allow periodic review and revocation of licenses if necessary, so that climate change impacts on water resources can be managed. The Water Act 2003 has given the U.K. government powers to extend this practice to licenses granted before 2001, and this matter is currently subject to a consultation exercise (for further discussion on water quality, see **Box 19** and **page 81**).

Box 19. Reduced Water Availability and Increased Energy Demand Leads to Forced Shutdowns and Reductions in Output for Power Plants and Other Businesses

Australian Drought Leads to Significant Reduction in Power Station Output

Tarong Energy (TE), a state-owned enterprise in Queensland Australia, owns the Tarong Power Station (TPS) and partly owns the Tarong North Power Station (TNPS). TE also own an adjoining coal mine that supplies the coal required for electricity generation at both stations. The ownership of the mine changed from Rio Tinto to TE in 2007.

The financial performance of TE in 2006/7 was significantly affected by the 2007 drought in South East Queensland (SEQ), with the corporation posting a loss for the first time in its history. In TE's annual report for 2006/7, losses of A\$ 68.6 million (after tax) were reported, due to reduced generation because of the drought, a change to the Australian International Financial Reporting Standards, and write-down of investment in TNPS.

The cooling system at TPS alone requires about 600 liters of water per second to make up for the evaporation losses in its two cooling towers. Water required for the cooling towers is obtained through a pipeline from Boondooma Dam. The power stations normally required approximately 35,000 ML of water per annum. However, the worsening drought conditions over 2006/7 led to restrictions on water use and a significant reduction in the stations' output.

The cut in power station outputs had a direct impact on upstream supply chains. In 2007, Rio Tinto was reported to have halved production of energy coal and cut 160 jobs at its Tarong mine in SEQ due to the cuts in power station output. Coal production was reported to drop from 605,000 tons per month to 300,000.

The drought also lowered water levels at hydroelectric power station dams in the Australian states of New South Wales, Victoria, and Tasmania. It was reported that wholesale electricity prices were up to four times higher than usual for the time of year because the drought had reduced supply at hydroelectric and coal-fired power stations.

Forced shutdown of Browns Ferry nuclear reactor in Alabama, USA

A heat wave in August 2007 forced the shutdown of a reactor unit at Browns Ferry. The plant uses cooling water abstracted from the Tennessee River to condense and cool the steam that it generates for its turbines. State environmental regulations impose a 90oF cap on the river temperature downstream of the plant to minimize stress to aquatic ecosystems. Typically, the plant increases the river's temperature by 5°F. During the heat wave, the upstream river temperature was often at or above 90oF, and the plant then became constrained by regulatory limits preventing it from raising the river's temperature further.

As a result, one unit at Browns Ferry was shut down, and power production from another two units was decreased, to reduce the quantity of process steam generated.

Sources: Delpachitra 2008; Ann and Batchelor 2007; "Heat Wave Shutdown at Browns Ferry Stirs Nuclear Debate," by Eric Fleischauer, September 2, 2007. Available at the Climate Ark Web site, <http://www.climateark.org/shared/reader/welcome.aspx?linkid=83238&keybold=climate%20blogs> (accessed August 20, 2009).

The following list provides some examples of how various aspects of pollution prevention and abatement may be affected by climate change. Many of these cross-sector climate risks are discussed in more detail in **Part II**.

- **Ambient air quality.**— Assessments of air quality impacts based on current ambient air quality may be flawed where changing climatic conditions, such as ground-level ozone concentrations, affect air quality.
- **Energy conservation.**— Increasing temperatures will increase the demand for cooling; therefore, energy efficiency, carbon reduction, and load targets may be not be met.
- **Wastewater and ambient water quality.**— Temperature limits for wastewater discharges intended to control the temperature of the receiving water body may be inadequate if the receiving water body is already at an elevated temperature due to heat waves or low flows. The additional temperature burden could exceed thresholds for aquatic organisms, resulting in ecosystem damage (see **Box 19**).
- **Water conservation.**— Water conservation programs may fail if water-cooled equipment produces additional cooling demands due to higher ambient temperatures.
- **Management of hazardous materials and waste.**— Prevention of uncontrolled releases and uncontrolled reactions may be compromised by increased incidence and severity of extreme weather events, such as flooding and heat waves.
- **Contaminated land.**— Changes in climate are likely to highly impact the physical movement of contaminants. Increases in rainfall intensity are likely to increase the erosion of contaminated soils, especially after dry periods. Changing environmental conditions also threaten the physical integrity of containment systems.
- **General facility design and operation.**— Evacuation and business continuity plans will require regular updating depending on the changing magnitude, frequency and nature of impacts.
- **Chemical and biological hazards.**— The potential for releases of biological hazards may increase (see **Box 17** above).
- **Water quality and availability.**— Due to climate change, availability of surface water and groundwater resources may be reduced by higher temperatures leading to more evaporation and evapotranspiration, along with changes in rainfall, snow and ice melt, and more frequent and intense droughts (see **Box 20**).

Box 20. Satellite Data Show Indian Groundwater Resources Are Shrinking Fast

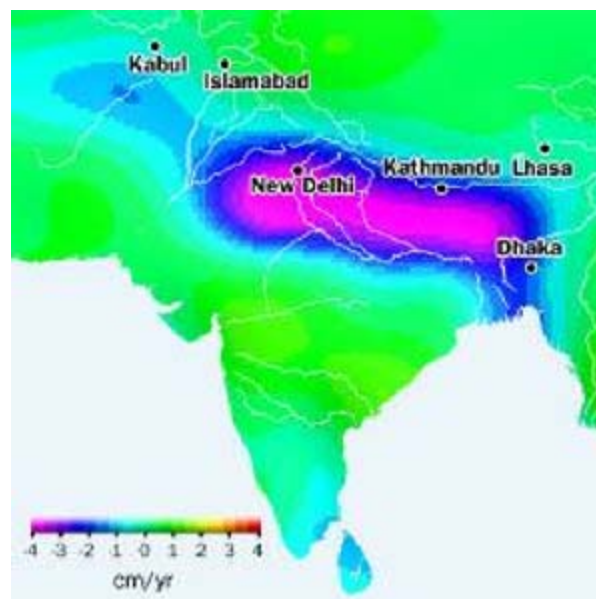
Groundwater is a key source of freshwater in many parts of the world. Some regions are consuming groundwater resources faster than they are replenished, causing water tables to decline dramatically. In India, unsustainable groundwater abstraction is threatening agricultural production and raising the possibility of a major water crisis. Two recent studies have used data from the Gravity Recovery and Climate Experiment (GRACE) satellites to measure how groundwater levels changed from August 2002 to October 2008.

One study, led by NASA, focused on the Indian states of Rajasthan, Punjab, and Haryana (including Delhi), which have a combined population of 114 million people and receive an average of 500 millimeters of rainfall per year, with pronounced seasonal and regional differences. While currently less than a third of the agricultural land in these states is irrigated, crop irrigation accounts for up to 95 percent of groundwater consumption. The study showed a net loss of 109 cubic kilometers (109 billion tons) of water from August 2002 to October 2008. As rainfall was close to the long-term average, the authors wrote that unusual dryness was unlikely to be the cause of the groundwater depletion and suggested that it was instead unsustainable consumption for irrigation and other uses. The amount lost is double the capacity of India's largest surface-water reservoir, the Upper Wainganga. While groundwater depletion in northwest India is a known problem, these data indicate that the rate of loss is about 20 percent higher than the Indian Central Ground Water Board had previously estimated.

A second study using GRACE data, by scientists at the University of Colorado and the National Center for Atmospheric Research in Boulder, Colorado, found that the most intensively irrigated areas in northern India, eastern Pakistan, and parts of Bangladesh are losing groundwater at an overall rate of 54 cubic kilometers per year, in line with the results of the NASA study (see figure below).

If measures are not taken soon to ensure sustainable groundwater usage, the consequences for the region may include a reduction of agricultural output and shortages of potable water, leading to increased socioeconomic stress. Climate change looks set to make matters worse. As temperatures rise, the need for irrigation water is likely to increase.

Depletion of Groundwater between April 2002 and August 2008, Based on GRACE Satellite Data



Sources: Rodell, Velicogna, and Famiglietti 2009; Tiwari et al. 2009; Tiwari, Wahr, and Swenson 2009 (source of figure)

Community Health, Safety, and Security

Project developers should address potential risks to and impacts on the communities affected by project activities, giving particular attention to natural hazards, such as landslides and floods. Such assessments should cover the project lifetime and take into account the potential for natural hazards to become more frequent or damaging as a result of climate change. If the risk of the project affecting communities changes over time because of the impacts of climate change (e.g., constraints on water resources), then the nature and frequency of community engagement will also need to change.

Developers can assess these risks by consulting qualified experts for project elements that are situated in high-risk locations or that could threaten community security if they failed (e.g., dams, tailings, ash ponds). Locations that are already at high risk today may become more vulnerable in the future; therefore, climate risk assessment and management should be seen as a necessity in these locations to protect the local communities (also see **page 92**).

An ESIA should identify individuals and groups that may be differentially or disproportionately affected by the project because of their disadvantaged or vulnerable status. The project developer should then propose and implement differentiated measures to minimize such adverse impacts.

Land Acquisition and Involuntary Resettlement

Developers should minimize involuntary resettlement where feasible and compensate the displaced people in those cases where there is no alternative. If unmanaged, resettlement can cause hardship and social stress as well as environmental damage in the areas into which displacement occurs.

Changes in land use as a result of project development may conflict with the current and future needs of the local community and its ability to adapt to a changing climate (also see **page 92**).

Changing climate risks could therefore increase the risk of damage to the livelihoods and living standards of displaced communities, if they are resettled in areas that are adversely impacted by climate change. Furthermore, project developers may not be able to provide a secure tenure for communities at their resettlement sites if changes in climate conditions (e.g., sea-level rise) force another migration or loss of land.

Climate change impacts could also increase the costs of resettlement. For example, resettlement to areas adversely affected by climate change could require higher payments in order to provide compensation to the resettled community equal to the value of its previous assets. Additional assistance and support facilities for resettled communities may also be needed in areas that will be significantly impacted by climate change, particularly to help them avoid causing further environmental damage by seeking access to already-scarce natural resources (e.g., groundwater in areas of water stress).

Biodiversity Conservation and Sustainable Resource Management

Conserving biodiversity and its ability to evolve is fundamental to sustainable development. The integration of conservation and development priorities requires assessment of the interactions between the two, which may change over time and as a result of climate change. Project developers should aim to prevent any conversion or degradation of natural habitats unless there is no feasible alternative, the overall benefits outweigh the costs, or there are management measures in place to restore the habitats.

Climate change is leading to significant changes in natural habitats and in the distribution of plant and animal species. Species are migrating at unprecedented rates as temperatures rise. So even if there are no species or habitats in particular need of conservation in the vicinity of a new development when it is constructed, there is no guarantee that protected species will not migrate into the area over the project's lifetime.

Alien invasive species may also migrate into the area around a project site, creating impacts on local agriculture and community health. Furthermore, valued species found in the vicinity of the site at the time of construction may migrate away in response to climate change.

Hence, mitigation measures proposed in an ESIA to protect species or habitats may prove ineffective as the climate changes. The developer may then be in the position of being unable to demonstrate that local loss of species or habitat damage has been caused by climate change, rather than by the development itself. Climate change might also make it more difficult to restore natural habitats, by altering the environmental conditions to which species are accustomed. Montane, wetland, and coastal ecosystems are at the highest risk.

The EU-funded BRANCH (Biodiversity Requires Adaptation in Northwest Europe under a Changing Climate) Project ⁹ investigated how spatial planning can help biodiversity adapt to climate change. BRANCH reviewed spatial planning policy relating to biodiversity and climate change (Piper et al. 2006: 6) and made the following recommendations:

“Where development projects are proposed, assessment of environmental impacts must also incorporate consideration of climate-change impacts and likely future climates. A risk-management approach that takes into account climate change when making planning decisions, using tools such as Strategic Environmental Assessment of plans and Environmental Impact Assessment of projects.”

⁹ See www.branchproject.org (accessed August 20, 2009).

Indigenous Peoples

Indigenous peoples are often among the most marginalized and vulnerable segments of the population and therefore require special attention. According to the UN Permanent Forum on Indigenous Issues,^h

“Indigenous peoples are among the first to face the direct consequences of climate change, owing to their dependence upon, and close relationship with the environment and its resources. Climate change exacerbates the difficulties already faced by vulnerable indigenous communities, including political and economic marginalization, loss of land and resources, human rights violations, discrimination and unemployment.”

Relationships with affected indigenous peoples should be established and managed throughout the life of a project, and the project should avoid adverse impacts on these peoples. In addition, projects should foster the long-term sustainability of the natural resources on which they depend.

Climate change is likely to increase the vulnerability of indigenous peoples who may already be disadvantaged by being marginalized (see **Box 21**) and who may have low adaptive capacity. In seeking development benefits for indigenous groups, project developers can look at opportunities to improve their adaptive capacity (e.g., by increasing their access to water and promoting or facilitating more climate-resilient sources of livelihood). This would likely require frequent monitoring and consultation with the indigenous peoples to ensure that climate change does not exacerbate currently manageable impacts of the project.

It should be noted that indigenous peoples are likely to be particularly vulnerable to the impacts of involuntary resettlement, discussed on **page 45**.

Cultural Heritage

Local cultural heritage should be protected from adverse impacts due to project activities. Project impacts on tangible and intangible forms of cultural heritage, including natural environmental features that carry cultural value, may be exacerbated by climate change, which may render current management practices inadequate. Extreme weather events may also result in migration of pollutants from project sites into culturally sensitive areas.

Local communities may not be able to discern changes to cultural sites caused solely by climate change from those caused by project activities. The implementation of programs to promote and enhance the conservation of protected areas may therefore require frequent monitoring to determine whether interactions with the project are in fact leading to their degradation. Sites that have been designated for the sole purpose of cultural use may also be adversely impacted, causing conflict and leading to a requirement for new sites to be provided by the project developer.

Research and analysis by the University College London Centre for Sustainable Heritage provides advice on how historic environments, encompassing historic buildings and collections, buried archaeology, and parks and gardens, can be helped to adapt to climate change (Cassar 2005).

^h See “Climate Change and Indigenous Peoples” on the UN Permanent Forum on Indigenous Issues Web site, http://www.un.org/esa/socdev/unpfii/en/climate_change.html (accessed October 10, 2009).

Box 21. Indigenous Communities in Argentina Struggle over Rights to Participate in Water-Resource Management

Water management is a divisive issue in Argentina, with a direct impact on the lives of the Mapuche Indians, indigenous peoples in the country's Patagonia region. In the Trahunco Valley, an international skiing resort is reported to be polluting a river in territory claimed by Mapuce communities.

While indigenous rights are formally recognized in the Argentinean national constitution, according to Alejandra Moreyra, a researcher funded by the Netherlands Organisation for Scientific Research, the Mapuce are being denied their rights by state institutions involved in water, natural resources, and environmental management. Local government water institutions proposed setting up a water users association (WUA) for the Trahunco Valley, but the Mapuce political organization was excluded from the plan to develop the WUA.

As a result, the Mapuce organized protests, sought support from other noninstitutional bodies, and took their case to the courts. The Mapuce call this "the new relationship with the state," in which they are demanding an equal footing with government bodies. However, Moreyra's research shows that local government bodies believe that territorial areas can be governed in a uniform manner, which ignores the rights of indigenous peoples. While the government is obliged to allow indigenous peoples to participate in the decision-making process, it defines "participation" as an invitation to stakeholders to be informed, and not as the right to be involved in the actual making of decisions.

As outlined elsewhere in this report, climate change is likely to lead to growing demand for increasingly scarce resources, further intensifying pressures on indigenous communities. As these communities become more vocal in demanding their rights, governments and businesses that fail to listen may be more exposed to disputes, conflicts, and reputational damage.

Source: ScienceDaily 2009

Conclusions

Climate change and its impacts will challenge the achievement of environmentally and socially sustainable projects. Using historical climate data to design projects and to conduct ESIA's may be inappropriate. Projects designed on the basis of such data may not be able to cope with new climate conditions, so mitigation measures developed through ESIA's and management plans may not function properly.

Some generic issues fall out of the analysis undertaken in developing this section:

- Analysis and management of climate-change impacts is needed over the whole project lifetime, through site selection, project design, management, monitoring, and decommissioning.

- Site monitoring, maintenance regimes, management practices, and community engagement practices must all be suitable in the light of climate change.

- Climate change will have differential effects: some sectors and geographies will be more affected than others, and it will be important to prioritize the key risks, to ensure proportionate, effective responses.

Reputation

Overview

Reputation is widely considered to be a strategic issue. A financial institution's reputation can be damaged both when its investments fail to achieve returns to society—by causing damage to surrounding communities or environments or failing to provide the expected development benefits—and when it does not demonstrate leadership in setting standards, policies, and good practices in the banking sector.

Climate change has the potential to create or exacerbate tensions that lead to reputational damage by modifying the relationships between investments and their surrounding environments and local communities. It is also changing stakeholders' expectations—including investment institutions' partners and competitors, such as the Equator Principles Financial Institutions.

Facilities designed based on historical climate conditions may not perform as intended. Their needs, as well as those of communities and environments for resources such as water, may change, increasing risks of conflict. Furthermore, because incremental changes in average climate conditions may go unnoticed for some time, investments may be undeservedly held responsible for impacts that are actually the result of changes in climate conditions, such as reduced water resources or water quality. As a consequence, there may be an increase in the number of cases where investments are perceived—rightly or wrongly—to worsen environmental or social conditions.

Investment institutions are under ever-growing scrutiny. Community or government opposition to a specific investment and public criticism of investment decisions are often relayed by the media or challenged legally or through other forms of settlement. Often, there does not need to be an established causal link between an investment and adverse social, environmental, or development impacts for the investment (and hence the investor) to suffer from bad publicity. It is enough for the investment to be perceived as the cause of degradation (see **Box 22** below).

Particularly sensitive climate-related issues that are likely to be sources of criticism against investment institutions include access to freshwater resources, freshwater quality and pollution, conservation of environmentally sensitive or protected areas, and resettlement and compensation of people affected by investments.ⁱ

If investors and their clients fail to manage these climate-related risks, this may lead to increased frequency and gravity of complaints received by them or reported in the media. This is particularly true for sectors and locations that are more exposed to the impacts of climate change.

At the same time, companies are in the spotlight due to concerns over their lack of governance and management of climate risks. Stakeholders—including investors, lenders, insurers, market and financial analysts, governments and regulatory agencies, consumers, local communities and NGOs—are putting greater pressure on companies to address climate risks.

ⁱ Issues of air pollution or property and physical damage may also be affected by climate change, although the effects will be of a more indirect nature. For example, more extreme weather events will threaten the safety of project assets and operations (see **Section**), with potential damage to the local community. Further, the frequency and gravity of occurrences of bad air pollution may change in the future because of changes in temperature, precipitation, and wind patterns (see **Section**).

Box 22. Glaciers, Climate Change and Community: Mining Operations in Chile

The plans of Canadian mining giant Barrick Gold Corporation to exploit gold, silver, and copper reserves at Pascua-Lama in Chile have been severely affected by community opposition. The project is located high in the Andes, near glaciers that provide drinking and irrigation water to downstream communities in the Huasco Valley (see figure), where agriculture is the main source of livelihood.

Location of the Pascua-Lama Project



Barrick believed it had ensured that its operations would have no significant impact on water quantity and quality by taking the following measures:

- years of monitoring of the project area,
- a mine design that minimizes the amount of runoff water coming into contact with mining operations,
- multiple barriers of active and passive protection against flooding, even in the case of extreme runoff events, during the life of the mine and after closure,
- avoiding operational discharges to the environment, and
- a comprehensive planned water quality monitoring and management program providing real-time data.

Source: <http://www.minesandcommunities.org/> (accessed August 20, 2009).

In February 2006, the project's environmental impact study was approved by Chilean authorities, provided 400 conditions were met. Nevertheless, communities surrounding the mine feared that the dust generated by the mining activities would deposit on the glaciers and speed their melting, while the mine operation would contaminate and divert the local water supply. Barrick argued that the glaciers are naturally dusty and have been receding for years because of climate change and that the mining project would have only a minimal impact on any acceleration of the melting.

The IPCC predicts with high confidence that over the coming decades, Andean intertropical glaciers are very likely to disappear. Studies demonstrate that many South American glaciers are already retreating because of changes in climate (see table).

Examples of Observed Trends in Glacier Retreat in Latin America

Glaciers/Period	Changes/Impacts
Peru ^a Last 35 years	22% reduction in glacier total area; reduction of 12% in freshwater in the coastal zone (where 60% of the country's population live). Estimated water loss almost 7,000 Mm ³
Peru ^a Last 30 years	Reduction up to 80% of glacier surface from small ranges; loss of 188 Mm ³ in water reserves during the last 50 years.
Colombia ^a 1990-2000	82% reduction in glaciers, showing a linear withdrawal of the ice of 10-15 m/yr; under the current climate trends, Colombia's glaciers will disappear completely within the next 100 years.
Ecuador ^a 1956-1998	There has been a gradual decline glacier length; reduction of water supply for irrigation, clean water supply for the city of Quito, and hydropower generation for the cities of La Paz and Lima.
Bolivia ^a Since mid-1990s	Chacaltaya glacier has lost half of its surface and two-thirds of its volume and could disappear by 2010. Total loss of tourism and skiing.
Bolivia ^a Since 1991	Zongo glacier has lost 9.4% of its surface area and could disappear by 2045-2050; serious problems in agriculture, sustainability of "bofedales" and impacts in terms of socio-economics for the rural populations.
Bolivia ^a Since 1940	Charquini glacier has lost 47.4% of its surface area.

Source: IPCC WGII 2007

Sources: IPCC WGI 2007; IPCC WGII 2007; Rohter 2006

The group of banks behind the Equator Principles has established a Climate Change Working Group (see the section on Barclays in **Box 23** below). Other banks, such as EBRD, are already integrating climate risk management into their investment appraisals. Failure by an investment institution to provide guidance and to serve as a model of how to assess and manage climate change risks in lending and other banking activities may negatively affect its reputation.

Increased Risk of Water Conflict Around Investments

Some developmental financial institutions are already facing criticism because of the implications of some of their investments for water availability. As climate change continues to affect the hydrological cycle, reducing water supply and increasing demand in some areas, the impacts of investments on freshwater resources will be under greater scrutiny.

Project activities that lead to water pollution may also increase. For example, to counteract changes in climate that decrease crop yields, farmers may use more fertilizers to maintain crop quality and/or output. Increased prevalence of pests and diseases or the introduction of new ones may lead to increased pesticide use.

Unless their investment process takes account of climate change impacts on water resources at both the investment appraisal and supervision stages, institutions may invest in projects that are more likely to face obstacles and reputational risks around water (see **pages 83 and 104**).

Increased Risk of Protests Against Projects in Environmentally Sensitive Areas

Investments in environmentally or culturally sensitive areas or protected land are vulnerable to protests and widespread criticism.

Because climate change will affect species, habitats, ecosystems, and cultural heritage, ESAs that do not account for these effects may be flawed. As a result, the cumulative impacts of climate change and investments may threaten vulnerable biodiversity, ecosystems, or cultural heritage or prevent their adaptation. For example, corridors for species migration may be obstructed.

Even in the absence of direct project impacts, species or habitats under threat from climate change will receive more attention, and investments in their vicinity will come under greater scrutiny and criticism unless they can demonstrate satisfactory management systems that take into account the climate change adaptation needs of the species or habitats.

Increased Risk of Protests Around Community Resettlement and Compensation

Community resettlement and compensation can be a major source of conflict for investments, particularly for metals and mining activities or large infrastructure projects.

When the communities surrounding projects have not been resettled, claims of adverse impacts suffered are sometimes stirred by changing socioeconomic or environmental conditions that bring hardship. Project developers who do not consider how climate change may degrade communities' future living conditions may fuel community resentment and suspicion and be unprepared to manage community conflict.

If project developers fail to take account of the ways that climate change will affect environmental and social conditions and of the resulting consequences for resettled communities, investment institutions may be exposed to reputational damage as climate impacts intensify.

A Lack of Action on Climate Change Adaptation Could Put a Financial Institution's Reputation at Risk

Climate change impacts are increasingly recognized by the financial community as a business risk issue with financial, credit, environmental, social, and developmental consequences. This is demonstrated through various initiatives:

- The Carbon Disclosure Project (CDP) represented in 2009 a total of 475 institutional investors across the world holding \$55 trillion in assets under management. The CDP sends out annual requests for information about management of climate risks, on behalf of its members, to the world's largest listed companies.
- Investors increasingly raise questions over climate change adaptation risks. There are many examples of investment funds undertaking research on the implications of climate change for future investment value.ⁱ
- In 2009, members of the Equator Principles, as well as the Climate Change Working Group of the United Nations Environment Program Finance Initiative (UNEP FI), debated the need for inclusion of climate risk management principles into financial institutions' guidelines, including the Equator Principles.
- In December 2008, an investor policy statement on the urgent need for a global agreement on climate change, including "support for adaptation to unavoidable climate change impacts" was produced by the Institutional Investors Group on Climate Change (IIGCC), the Investor Network on Climate Risk (INCR) and the Investor Group on Climate Change in Australia and New Zealand (IGCC). Signed by 181 investment institutions that collectively represent assets of \$13 trillion, the statement called for clear, credible long-term policies on climate change to be agreed upon in Copenhagen in December 2009 and stated that "as

investors we recognize that the physical impacts from climate change will have far-reaching consequences, such as rising costs of insurance and scarcity of key resources, including water scarcity risks. At present, both government and private sector investment in adaptation is inadequate across the globe." (IIGCC, INCR and IGCC Australia/New Zealand 2008: 4).

ⁱ See, e.g., Acclimatise, "Investors Raise Questions over Climate Change Adaptation Risks," January 23, 2008, at <http://www.acclimatise.uk.com/news/investors-raise-questions-over-climate-change-adaptation-risks>, and the Institutional Investors Group on Climate Change Web site, at <http://www.iigcc.org/index.aspx> (both accessed September 20, 2009).

Through its governance and standards, a financial institution can serve as a role model and leader for other banks. Leadership brings with it a “first mover” or competitive advantage and therefore is considered a strategic objective by businesses across sectors.

Major banks, such as EBRD, AfDB, ADB, and Barclays, are already beginning to mainstream climate change risk management into their due diligence investment appraisal and monitoring processes (see **Box 23**).

In this fast-moving context, institutions risk falling behind and losing their leadership positions if they fail to act as models of how climate change risks may be assessed and managed.

Box 23. Climate Change Risk Management in Investment Banks Worldwide

European Bank for Reconstruction and Development (EBRD)

A 12-month project has been initiated by EBRD, with financial support from the U.K. DFID, to develop a methodology for understanding the risks posed by climate change and their impacts on the bank’s operations, so that investment projects can be made climate-resilient where appropriate. The project is developing guidance and practical tools to integrate climate risk assessment and adaptation into EBRD’s project cycle management. In order to develop the approach and learn lessons, 12 case studies of EBRD investment projects have been examined, across a range of sectors and geographies. Additionally, the project will also begin to identify new business areas for EBRD where pro-adaptation investments could boost the climate resilience of the bank’s clients and its countries of operations.

EBRD is also participating in the Pilot Programme for Climate Resilience (PPCR) in Tajikistan, implemented under the Climate Investment Fund. PPCR will pioneer pro-adaptation technical assistance and investment projects.

African Development Bank (AfDB)

AfDB has developed a Climate Risk Management and Adaptation Strategy that seeks to reduce climate vulnerability within the bank’s regional member countries and promote climate resilience in past and future bank-financed investments, as well as to build capacity and knowledge in the bank’s regional member countries on climate change adaptation. The strategy focuses on three key areas of intervention: “climate-proofing” investments, policy, legal and regulatory reforms and knowledge generation and capacity building

All of AfDB’s due diligence procedures will be revised to incorporate climate risks. As part of the due diligence process in each department, task managers will carry out a quick screening of project and program proposals to identify country-, region-, and sector-specific climate risks during project design. AfDB’s operations safeguards will also be amended: the bank’s ESIA guidelines will be replaced by new, more comprehensive environment, climate, and social impact assessment (ECSIA) guidelines. AfDB also supports capacity-building initiatives on climate change adaptation, such as Climate Information for Development in Africa (Clim-DeV Africa), which aims to mainstream climate information into decision making for African development.

Asian Development Bank (ADB)

ADB has an adaptation program that provides operational support to Asian and Pacific economies to enhance their resilience to adverse climate change impacts by mainstreaming adaptation into national, sectoral, and project-level plans and actions. In particular, much of ADB’s effort is focused on predicting project-level climate change impacts, designing adaptation options, and evaluating the costs and benefits of adaptation options. This is undertaken through the four core elements of ADB’s program: ‘national adaptation assessments and planning with ADB’s support’, ‘increasing the climate resilience of vulnerable sectors’, ‘“climate-proofing” projects’ and ‘addressing social dimensions’.

(continued on next page)

ADB has developed a Climate Screening Tool to take into account climate-induced risks and natural hazards. The tool will expand ADB's risk assessment capacity within its policy framework and project life-cycle operations. It aims to make investments more resilient to risk. ADB also led on the execution of six case studies, using a risk-based approach, which presented and explained methodologies for the reduction of climate-related risks in the context of climatically-vulnerable countries.

Inter-American Development Bank (IADB)

IADB's Sustainable Energy and Climate Change Initiative accepts funding proposals with the objective of improving climate resilience in Latin American and Caribbean countries.

Barclays

Barclays has supported the London Accord, which is a U.K. partnership that acts as a medium for the publication of insights from financial services companies on issues related to climate change. In this context, Barclays Environmental Risk Management, in partnership with Acclimatise, produced a report that investigated the credit-risk impacts of a changing climate for five key sectors known to be vulnerable: long-lived assets generally; chemicals and pharmaceuticals; fossil fuel and power generation, supply, and distribution; renewable power generation, supply, and distribution; and tourism. It also provided examples of risk-management actions that could help to manage climate-related risks to project performance. Added to this, Barclays Environmental Risk Management currently leads the Equator Principles Climate Change Working Group, which is the conduit through which the Equator Principles Financial Institutions (EPFI) liaise with IFC on climate change issues.

HSBC

HSBC has set-up its Climate Change Centre of Excellence which analyzes the commercial implications of climate change for HSBC Group businesses and clients. The Centre is to be HSBC's integral hub of climate change knowledge, with the aim of enhancing understanding of the risks and opportunities of climate change and ensuring their integration into HSBC's core financial services business.

Banks in partnerships

Barclays, HSBC, and EBRD, together with the DFID and Forum for the Future, are members of the Climate Resilient Investment Work Stream of the U.K. Financial Sector Task Force on Climate Change Adaptation. Its aim is to encourage debate around the potential roles of the investment community in helping to address the physical risks of climate change in developing countries. In 2008, the group worked together on a discussion paper that explains the importance for businesses of seriously considering climate change adaptation, identifies crucial actions that can be undertaken by businesses, and emphasizes how adaptation strategies can be developed in partnership with governments and communities.

Standard Chartered is part of the Economics of Climate Adaptation (ECA) Working Group, which has undertaken research on how to design climate-resilient economic development strategies. In 2009, ECA published a study aimed at providing decision makers with a set of tools to assess the risks related to climate change, develop adaptation strategies, and determine the level of investment required to fund these strategies.

Regardless of whether future climate change projections are taken into account by these banks, these examples show the industry recognition of the potential materiality of current climate risks.

At present, there is no commonly accepted method or tool to assess and manage climate risks in the investment community. However, a wide range of tools have been developed and tried by various organizations in recent years. For a list of these, see "Mainstreaming Tools and Methods" on the GTZ Web site (see below).

<http://www.gtz.de/en/themen/umwelt-infrastruktur/umweltpolitik/27678.htm> (accessed October 15, 2009), or UNDP's "Stocktaking of Tools and Guidelines to Mainstream Climate Change Adaptation" <http://www.undp.org/climatechange/library.shtml> (accessed April 10, 2010).

Sources: ECA 2009; Furrer, Hoffmann, and Swoboda 2009; Acclimatise and Synergy 2008; ADB 2005, 2007; Bray, Colley, and Connell 2007; Van Aalst et al. 2007; AfDB et al. 2005; Ponzi 2007; "Bank Group Rolls Out Climate Risk Management and Adaptation Strategy," April 30, 2009, AfDB Web site, <http://www.afdb.org/en/news-events/article/bank-group-rolls-out-climate-risk-management-and-adaptation-strategy-4526/>; http://www.afdb.org/fileadmin/uploads/afdb/Documents/Generic-Documents/0163_EN_SESSION1-CLIMATE_CHANGE.ppt "ADB and Climate Change Adaptation," ADB Web site, <http://www.adb.org/Climate-Change/cc-adaptation.asp>; London Accord Web site, <http://www.london-accord.co.uk/>; HSBC Web site, <http://www.hsbc.com/1/2/sustainability/protecting-the-environment/climate-change> (all sites accessed June

Conclusions

Unless the risks are proactively addressed, project financial, economic, developmental, environmental and social performance may deteriorate under a changing climate, with consequences for financial institutions' reputation. Even the perception that an investment is responsible for environmental or social degradation can be sufficient to stir community protests and attract negative media attention.

It is not possible to estimate the financial consequences of increased reputational damage due to failure to address climate risks. However, as the sum of perceived values that stakeholders attribute to a company, reputation does carry a financial value. Climate change–related damage to an institution's reputation may lead to or exacerbate indirect financial liabilities, leading to consequences such as increased cost of public relations, difficulty recruiting high-caliber staff, the potential for decreased access to some financial markets (e.g., because of damaged sustainability credentials), and erosion of trust among existing and potential clients.

Institutions' communication strategies may need to start accounting for the importance of having a reputation of undertaking and being seen by investors and stakeholders to be undertaking climate change risk management.

OPERATIONAL RISK

Operational risk can be defined as “the risk of direct or indirect loss due to inadequate or failed internal processes, people, and systems, or from external events” (BCBS 2003).

Financial institutions may already identify, assess, monitor, and report on operational risks inherent in their own operations and support business process owners in effective management of these risks. However, changing climate conditions, if unmanaged, may present additional risks to institutions’ processes, people, and systems. Investments may fail to perform as expected, business activities may be disrupted, and contingency plans may prove inadequate. Unless an institution’s risk management methodologies and tools integrate considerations for climate change, its risk position may be underestimated (EIU 2009).

Processes

A good practice for all institutions is to define roles and responsibilities for managing climate risks across all departments and activities. Managing climate risks is now widely seen as a matter of good corporate governance, as witnessed by the Carbon Disclosure Project (CDP) and other initiatives. Financial institutions’ governance and management of climate risks will be increasingly scrutinized as other organizations continue to develop and mainstream their own approaches (see [page 52](#)).

Climate-related risks to investment appraisal processes (credit risk analysis, financial risk analysis, environmental and social assessment, and development appraisal) are discussed in detail on [pages 8-25](#). As highlighted there, unless these appraisal processes consider the impacts of climate change appropriately, they may become less effective in selecting and designing investments that will perform successfully.

As financial institutions examine their current management of operational climate risks, skill gaps may emerge: staff responsible for these appraisals may lack the awareness, training, tools, and techniques to assess and manage climate risks in line with emerging good practice. Given the complexities and uncertainties surrounding the impacts of climate change on investments, in the absence of process guidance from the center, there is a danger that staff may undertake assessments in an ad hoc manner, creating inconsistency across an institution.

Climate change has the potential to affect investment institutions’ work quality if climate risks are not factored in during the project appraisal stage, causing project performance to decline over time; if the emerging impacts are not appropriately monitored and managed as part of project supervision; or if staff do not have the knowledge or technical expertise to assist clients in climate-risk management.

The work quality of an investment institution can be broken into three categories:

1. Screening, appraisal, and structuring of projects
2. Supervision and administration
3. The institution’s role in and contribution to the success of a project (e.g., through its knowledge, awareness of best practices, technical expertise, combination of investment and advisory services, investment perspective, and brand and reputation)

Evaluating work quality in these categories can help an institution learn from its experiences, supply an objective basis for assessing the results of its work, and provide accountability in achieving its objectives.

Staff, Buildings, and IT Systems

Financial institutions with global operations may have some offices and investments located in countries that are more susceptible to natural disasters or where national infrastructure (energy, water, telecommunications, etc.) is already vulnerable to dislocation. As risks are changing, current views of the operational risks for different countries may be underestimating their true extent or missing some risks altogether.

Climate change will affect various aspects of buildings, including the external building fabric, structural integrity, internal environments, and supporting service infrastructure (drainage, water, waste, energy, telecommunications, and transport). The extent of the risks will depend on the design and location of the building and its surroundings. At present, most buildings and infrastructure globally are designed on the basis of historical climate data without consideration of the climatic conditions that the

buildings will experience over their lifetimes. As a result, their performance will be increasingly affected. There will be incremental changes—for instance, at the point when an air conditioning system can no longer provide a comfortable internal environment and staff productivity is affected, or when drainage systems are overwhelmed by heavy rainfall that exceeds their design standards.

Higher temperatures will have increasingly serious implications for staff comfort, productivity, and risk of heat stress. They will also lead to increased demand for cooling in buildings, and consequent increased energy use and GHG emissions, particularly in high-density areas where the urban heat island effect is more pronounced. Demand for space heating and related energy consumption will, however, decrease. High temperatures and drought will increase risks of fires affecting rural and urban areas, as seen in August 2009 in Athens, Greece.

As discussed in more detail in on **pages 83 and 104**, changing patterns of precipitation will have significant implications for water resources and availability, water quality, and flood risk. Increased flood risk for buildings and their surroundings can lead to loss of life, injury, disease, mental stress, damage to buildings and their contents, contamination from sewage, and access problems. Extreme precipitation events can force office buildings to close altogether, halting or severely limiting operations as well as causing major productivity losses for employers and recovery costs for local governments (see **Box 24**).

Box 24. Record Washington-Area Snowstorms Led to Massive Operational and Recovery Costs for Local and Federal Governments

Record-breaking snowstorms repeatedly hit the Washington, DC, area in the winter of 2009/10, closing schools and government offices, knocking out power to thousands of homes, blocking streets, and canceling flights and local rail service.

After the first major snowstorm of the winter, on December 18, President Barack Obama declared the capital region a federal disaster area. The State of Virginia subsequently requested approximately \$49 million in federal assistance to cover the costs of snow removal, some infrastructure damage, removal of debris, and storm-related emergency services. Following back-to-back snowstorms between February 5 and 11, which prompted another federal disaster declaration, officials in Prince George's County, Maryland, estimated having overspent their snow-removal budget for the year by \$9–\$10 million. The Washington Metropolitan Area Transit Authority suffered snow-removal costs and lost revenue totaling approximately \$18 million.

The February storms also caused the federal government to close down for four consecutive days. The Office of Personnel Management estimated that the cost of lost productivity from these closings was \$71 million per day. This figure was originally estimated at \$100 million per day, but was reduced after accounting for a number of government employees who were able to work from home. Members of the House of Representatives advanced legislation to promote such "telework" in future emergencies requiring shutdown of federal office buildings.

A weather expert writing for the *Washington Post* conjectured that the storms were the result of natural factors such as El Niño and the Arctic Oscillation and noted that evidence showed that the planet as a whole was continuing to get warmer. At the same time as the DC area was being blanketed by snow, most of the globe was experiencing warmer-than-normal temperatures. Canada had its warmest and driest winter on record, and Western Australia experienced record-high summer temperatures.

According to IPCC projections, based on various assessments of the current climate models there is no consistent indication at this time of discernable changes in projected El Niño Southern Oscillation (ENSO) amplitude or frequency in the 21st century. However, the majority of climate models point to an increase in the strength of the Arctic Oscillation, which is statistically significant early in the 21st Century. According to a recent conference which drew together 2,300 Polar scientists, changes in the Arctic's climate are happening faster than had been previously predicted, and may lead to more cold and snowy winters in future in eastern North America, like the one seen in Washington, DC in 2009/10.

Sources: Kravitz 2010; Halsey 2010; Mummolo and Marimow 2010; Freedman 2010; IPCC WG I 2007; Overland 2010

Properties in highly flood-prone areas will become increasingly expensive to insure, and some may become uninsurable. More intense precipitation will also affect building facades and internal structures and lead to more rain penetration around openings.

Changing rainfall and temperatures will also affect the risk of landslides on slopes and embankments, potentially threatening buildings, land, and infrastructure in vulnerable locations. Increased rates of subsidence and heave are already being seen in property and underground service infrastructure on clay-based soils (see **Box 25**).

In addition to heat stress, staff and contractors will be increasingly exposed to other health risks, particularly in locations with high population density and levels of urbanization. Some locations where current health hazards are low will become more risky in the future. The health consequences of climate change will depend on the preexisting health status of the exposed population, and staff are perhaps less vulnerable than contractors. However, all will be exposed to changing occupational hazards.

Changes in climate have already altered the distribution of some infectious diseases—including malaria, meningitis, dengue fever, and tick-borne diseases—and these will continue to change. Similarly, climate change is altering the seasonal distribution of some allergenic pollen species (IPCC WGII 2007). Under warmer temperatures and changing rainfall, the burden of diarrheal and cardiorespiratory diseases may increase. For additional discussion, see **page 94**.

Box 25. Recent Pattern of Drought Followed by Heavy Rains Causes Unprecedented Damage to House Foundations

According to a report in the *New York Times*, extreme weather possibly linked to climate change has provoked an unprecedented spate of foundation failures in houses throughout the United States. In times of extreme drought, soil has contracted, causing house foundations to crack and sink. Frequently, these periods of drought are followed by heavy rains and flooding, which can push sunken foundations back up, causing further structural damage. Such movements can cause walls to crack, tiles to break, and chimneys and porches to separate from houses.

The National Oceanic and Atmospheric Association has collected evidence of a pattern beginning in the 1990s of extended dry periods followed by heavy rain or snow, which may be due to climate change or simply to random climate patterns. This pattern is likely accelerating the shifting and sinking, or subsidence, of both clay and sandy soils. The effects of this acceleration are compounded by the fact that newer homes were often built in areas that had less stable soil to begin with and may have been designed without adequate consideration for the ground conditions, as development expanded rapidly to meet the demands of the recent housing boom.

Homeowners currently spend about \$4 billion each year to stabilize or shore up foundations, up from \$3 billion a decade ago. Most states set a statute of limitations allowing only 8–10 years following the completion of a house for homeowners to sue for inadequate construction given the soil conditions, and damage caused by subsidence is not covered by most U.S. home insurance policies. Homeowners insurance in Britain does cover such damage, however, and the increase in claims there has been cause for alarm in the insurance industry.

This trend points to a need to update building codes around the world in order to cope with the effects of changing weather patterns. Home buyers may also need to hire geotechnical engineers to conduct inspections in addition to regular home inspectors, who may not have the expertise to assess soil conditions.

Source: Murphy 2010

Information technology (IT) hardware, and in particular data centers (which may be managed internally or by external providers), are vital to any institution's business continuity and will be increasingly vulnerable to the risks outlined above. The specific operational risk implications for IT systems include the following:

- Additional burden on IT cooling equipment from increases in temperature and increased frequency of heat waves
- Reduction in operational efficiency of IT hardware and increased component failure rates as temperatures rise. As server processors become more powerful, their operational efficiency continues to rely heavily on cooling systems. The space around server racks is now commonly cooled by air flow, though some are also water-cooled. The American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) recommends an operating temperature range of 20°C–25°C for IT equipment. If temperatures go beyond the supported range, failure rates can increase significantly. Research has shown that the failure rate for high-performance computing equipment doubles with a temperature rise of 10°C (Bayle 2007).
- Restricted supplies of water for cooling during periods of intense drought
- Damage to IT equipment and potential loss of data through flooding of buildings
- Damage to overhead cables from storms and subsidence damage to underground communications infrastructure, with significant cost implications
- Damage to upstream/downstream communications infrastructure
- Loss of business continuity

As climate change is accelerating, existing contingency plans for IT systems may not adequately recognize the risk of climate-related disruptions. Where an institution relies on outsourcing to third-party data center providers, it must be assured that their contingency plans also recognize the changing nature of these risks.

LEGAL RISK

Overview

Because climate change can lead to an increase in all of the types of corporate risks discussed above as well as to an increased risk of damage to third parties from investment projects, unless it is managed, it may also lead to disputes between investment institutions and their clients and/or between institutions and third parties (e.g., local communities, co-investors, and project end users).

This section discusses two key areas of legal risk for investment institutions:

- Duty of care and skill in providing professional advisory services to clients
- Duty to act in the interests of the institution itself

The status of climate-risk disclosure and management is changing from voluntary activities to mandatory requirements. This is evidenced by recent changes (or proposals for changes) to statutes and regulations that make climate-risk disclosure and management mandatory. These changes supplement the duty that company directors already have to disclose future material risks to their shareholders in their annual reports.

As mentioned on **page 24**, in January 2010 the U.S. SEC issued new guidance to provide clarity and enhance consistency for public companies and their investors. In particular, it advises that firms should assess whether the physical impacts of climate change will have a material effect on their operations and analyze how climate-related legislation and international treaties could impact their business. It also notes that technical and market developments related to climate change could have a material impact on a firm; for example, some firms may face decreased demand for goods that produce significantly more GHG emissions than competing products (U.S. SEC, 2010).

The issue of disclosure is of increasing interest to investors. For example, UNEP FI has considered this issue in two landmark reports on fiduciary duties and environmental, social, and governance (ESG) issues: the “Freshfields Report” of 2005 and the follow-up report in 2009 (UNEP FI AMWG 2005, 2009). These reports consider, in the context of investment and asset managers, that the inclusion of ESG considerations (which include climate change impacts) into investment analysis is compatible with the duties fiduciaries owe their beneficiaries, and indeed is arguably required in all jurisdictions.

Some lawyers are beginning to acknowledge that there is now sufficient information available on climate change for it to be taken into account in both strategic and operational decision making. This means that climate change may be close to attaining “legal significance” in court (LCCP Finance Group 2009); indeed, it has already affected judicial decisions, as well government policy, in Australia (see **Box 26**). If climate change impacts are considered “reasonably foreseeable” by a court, decisions that do not take these impacts into account may incur liability in negligence:

“The effects of climate change can now be regarded as being reasonably foreseeable at every stage—from initial construction, through the design and planning process to construction and beyond; it must be incumbent upon professional advisors to ensure that appropriate steps have been taken” (Dowden 2005; Dowden and Marks 2005).

Reasonable foreseeability is likely to be established on basis of the existence of “knowledge points” after which it is reasonable to consider that the impacts of a changing climate should have been known. Potential knowledge points that could be used to challenge decisions may include (without being limited to):

- The scientific evidence established, recognized, and widely available since the IPCC’s *First Assessment Report* (published in 1990), the Stern Review (Stern 2007), and other landmark expert reports.
- The increasing evidence of the business consequences of climate change across sectors (e.g., in the water, agriculture, energy, finance, and insurance industries).
- Public statements by industry leaders who would naturally be expected to resist the message acknowledging that climate change holds business risks and needs to be managed. A strong example is the 2003 speech by Lord Browne, then CEO of BP, to the Institutional

Investors Group on Climate Change, acknowledging that “based on scientific evidence so far there is a cause for concern.”

^k The oil and gas company BG Group is another industry leader that relies upon large fixed assets and has publicly recognized the climate change risks to its operations. In its 2008 Sustainability Report, the company recognized climate change as a key corporate risk area (BG Group 2008). BG Group has implemented a mandatory standard governing climate change adaptation and adopted a Climate Risk Management Framework to support assets and projects in delivering against the standard’s requirements (see further details in **Box 16** above).

- The World Bank’s and IFC’s publications on climate change, such as those published through IFC’s Adaptation Program and the series of reports prepared in collaboration with the WRI highlighting climate change–driven risks and opportunities currently overlooked by investors and companies in Asian emerging markets (Krechowicz and Fernando 2009a, 2009b; Krechowicz et al. 2010; Venugopal et al. 2010; Sauer et al. 2010).
- Guidance from professional institutions and bodies guidance to their members (e.g., insurers, engineers, accountants, architects, and transport planners). Membership in any professional institution usually requires keeping one’s professional knowledge updated with a duty of care to employers and clients.

^k At the same time, companies are in the spotlight due to concerns over their lack of governance and management of climate risks. Stakeholders—including investors, lenders, insurers, market and financial analysts, governments and regulatory agencies, consumers, local communities and NGOs—are putting greater pressure on companies to address climate risks.

Box 26. Increasing Consideration for Climate Risks in Courts and Government Bodies across Australia Has Implications for Development Planning and Insurance

Court cases

Recent cases have demonstrated the willingness of courts and planning tribunals across various Australian jurisdictions to accept evidence of climate change risks and to emphasize the need for development applicants and consent authorities to take account of such risks—particularly the impact of rising sea levels—when planning their developments.

The Victorian Civil Administrative Tribunal refused to approve a development proposal to subdivide an area of coastal land after receiving the results of a coastal hazard vulnerability assessment, which considered issues including sea-level rise, storm tide and surges, coastal processes, and local topography and geology. The tribunal held that granting a development approval in the circumstances would result in a poor planning outcome and would unnecessarily burden future generations.

The New South Wales Court of Appeal found that although local law regarding environmental planning and assessment does not expressly require that principles of ecologically sustainable development (ESD) be taken into account by a consent authority, the “public interest” is broad enough to embrace ESD principles. The court held that ESD principles are likely to be an element of public interest in relation to most planning decisions in coastal areas, and failure to consider ESD would provide strong evidence of failure to consider the public interest.

Policy changes

Recent policy developments at the local, state, and federal levels indicate a similar trend. A National Sea Change Taskforce was set up in 2004 to coordinate local councils’ approach to managing climate change impacts on sea level and ensuring that coastal development is managed with a focus on the sustainability of coastal communities and the coastal environment. In addition, several Australian states have issued or are currently drafting policies regarding sea-level rise and coastal development.

At the federal level, a bipartisan parliamentary committee conducted an inquiry in 2009 into climate change and environmental impacts on coastal communities. Key recommendations of the resulting report include the following:

- Establishment of a new Coastal Zone Ministerial Council to develop an Intergovernmental Agreement on the Coastal Zone endorsed by the Council of Australian Governments
- A separate funding program for infrastructure enhancement in coastal areas vulnerable to climate change
- An Australian Law Reform Commission inquiry into the liability issues facing public authorities and property owners in respect to climate change
- A Productivity Commission inquiry into insurance coverage for coastal properties

Practical implications

These case-law and policy trends mean that developers in coastal areas will need to assess the potential for sea-level rise, increased storm severity, flooding, and other climate change impacts on their projects and to incorporate appropriate adaptation measures in their design proposals. Developers will have greater potential to sue local consent authorities for damage or loss suffered where it can be said that the development consent was granted negligently. However, developers’ own contributory negligence in failing to consider climate risks and devise their own adaptation measures will be relevant in such suits.

Property owners in existing developments will increasingly need to implement adaptation strategies to ensure that their assets are preserved over their life spans. These measures will come at a cost, but planning now for climate change could stave off greater losses that owners would otherwise incur from infrastructure and asset damage in the future.

Local councils may be held liable for climate-related damage to the extent that they are negligent in granting development consents. Additionally, as scientific evidence improves and local climate change impacts can be forecasted with more certainty, it is likely that councils will adopt a more conservative approach in granting development approvals.

One of the more immediate threats for property owners and developers in coastal areas is the recent surge in insurance premiums and their availability. As sea levels rise and coastal erosion continues, insurance may become increasingly and potentially prohibitively expensive. Therefore, it would be prudent for developers and owners to factor this future cost into their development planning.

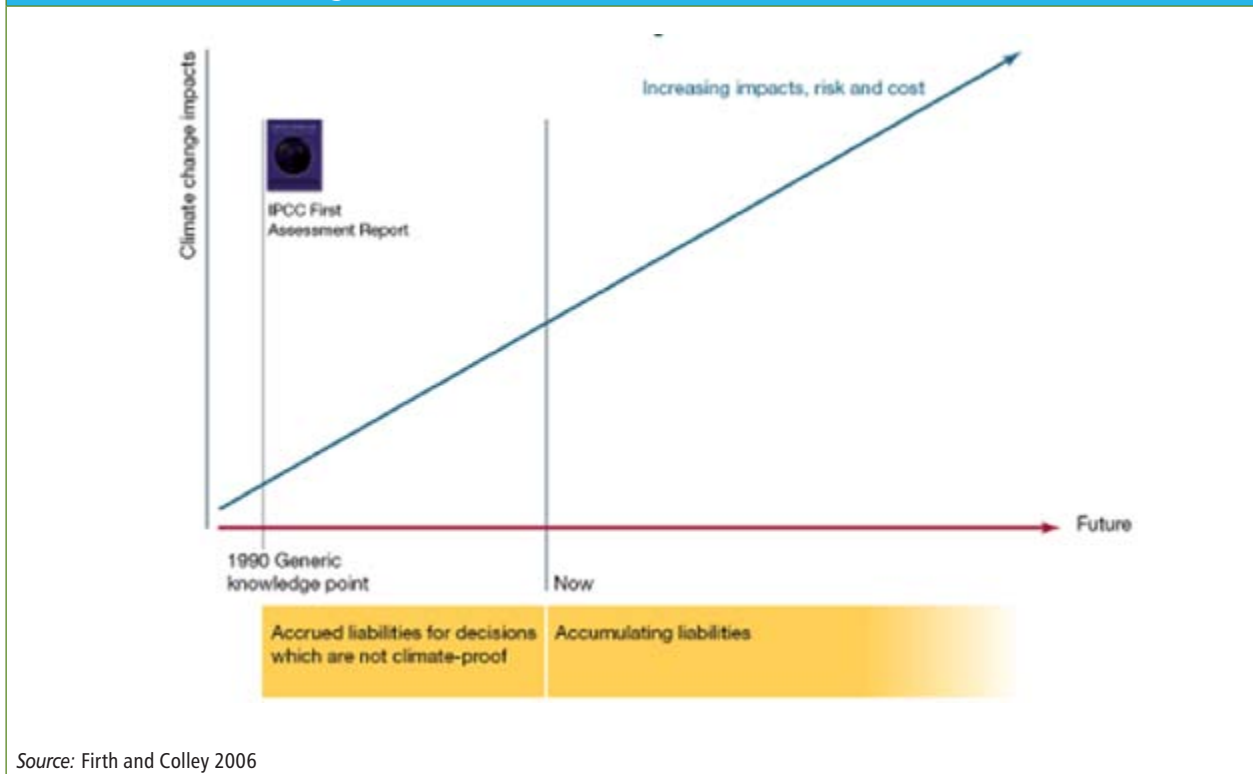
Source: “Climate Change Litigation to Flood Planning and Development in Coastal Areas,” February 12, 2010, Freehills Web site, <http://www.freehills.com.au/5789.aspx> (accessed March 25, 2010).

Figure 3 identifies the effect of climate change knowledge points on legal risk. Any of an investment institution's decisions since the dates of knowledge points may have accrued liabilities in the event that the decisions did not

consider climate change impacts that were reasonably foreseeable. Liabilities may continue to accumulate through the failure to build climate change into current and future decision making. If the institution is challenged, it may find

it difficult to argue against claims of negligence for not considering climate change risks.

Figure 3. Illustration of Increasing Liabilities on Professional Advisers as Climate Change Risks Increase



Source: Firth and Colley 2006

Duty of Care, Skill, and Caution in Providing Professional Advisory Services

When a financial institution acts as a professional adviser through its advisory services, it is bound in its professional discretion by law, contract, and negligence.

In general, professional advisers are required to exercise reasonable care, skill, and caution in pursuing their mandates (under U.S. law) or to act prudently and for a purpose (under U.K. law). Similarly, in other countries legislation imposes a duty to act diligently, professionally, or prudently.

For all risk issues that are relevant and material to the advice given, professional advisers, under a (paid) contract for services, have a duty to act as experts and advise their clients on these risks, even without being prompted or questioned by their clients.

As described elsewhere in this report, climate change can have significant business impacts, depending on the climatic vulnerability of the business (which in turn depends on its exposure, sensitivity, and adaptive capacity). As a result, climate risks may be relevant and material to a financial institution's advice.¹ In these cases, and especially when there are climate change knowledge points, the institution has a duty to act diligently in the consideration of all material climate change risks, if the law of the contract between the institution and its client or the contractual dispositions do not state otherwise—and even if the client does not request it. This idea is confirmed in the UNEP FI Freshfields report:

Integrating ESG considerations [among which UNEP FI includes climate change risks] into an investment analysis so as to more reliably predict financial performance is clearly permissible and is arguably required in all jurisdictions (UNEP FI AMWG 2005, p. 13).

Failure to consider climate risks may be considered an act of professional negligence. Regarding private professional advisers in general, failure to consider ESG issues “could lead to a very real risk that they will be sued for negligence on the ground that they failed to discharge their professional duty of care to the client” (UNEP FI AMWG 2009, p. 15).

This failure to take the reasonably anticipated impacts of climate change into account may give scope for claims in contract or tort. Institutions providing advisory services should also consider the potential implications for their professional liability insurance coverage.

In practice, for example, when advising on the engineering design and financial structuring of a future hydropower facility, an investment institution has to consider whether the project design is robust considering future river-flow and cash-generation profiles, and whether the project can operate efficiently and safely during its useful life. Future changes in climatic conditions that could change river flow or affect flood return periods could affect project performance and invalidate some of the institution's recommendations.

¹ UNEP FI (2009, p. 28) acknowledges the material nexus between investment value and climate change risks.

Climate Change Risk Management as Part of Fiduciary Duty

A parallel can be drawn between the duties a company's directors have toward their shareholders and the relationship between an investment institution and its investors. In this context, some of the conclusions of the UNEP FI reports may be relevant:

Fiduciaries must recognize that integrating ESG issues into investment and ownership processes ... **is necessary to managing risk and evaluating opportunities for long-term investment.**

Fiduciaries will increasingly come to understand the materiality of ESG issues and the systemic risk it poses, and the profound long-term costs of unsustainable development and its consequent **impacts on the long-term value of their investment portfolios.** (UNEP FI AMWG 2009, p. 11)

Financial institutions should take steps to understand the materiality of climate-change risks to their own long-term value. If an institution does not have regard for climate-change impacts on long-term value creation, it may be considered not to be acting in the best interests of its investors.^m

Further, UNEP FI recognizes that the integration of ESG issues into decision making may be required if the mandate given to a company requires as much:

ESG considerations must be integrated into an investment decision where a consensus (express or in certain circumstances implied) amongst the beneficiaries mandates a particular investment strategy. (UNEP FI AMWG 2005, p. 13)

Developmental financial institutions' development goals, such as reducing poverty and improving lives in developing countries, may not be achieved if their investment strategies are not climate-resilient (see **Sections 3 and 4**).

Conclusion

A dispute with a financial institution based on either of these two legal grounds (professional duty of care and fiduciary duty) may or may not develop into a legal case. However, regardless of the nature of the dispute, the institution's reputation is likely to be damaged, for example, if there are criticisms against it for supporting projects that later cause damage or fail because they did not account for climatic changes. Further, if an institution ignores climate change as a corporate risk issue, despite evidence of such risk, the institution's governance may be criticized, especially in relation to other banks (see **Section 4**) and governments that are taking actions to adapt to a changing climate.

^m A survey conducted by Lloyd's and the Economist Intelligence Unit in 2008 revealed that company directors are concerned about emerging environmental liabilities in the context of climate change and increased scrutiny of corporate environmental performance (Lloyd's and EIU 2008).

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Part II

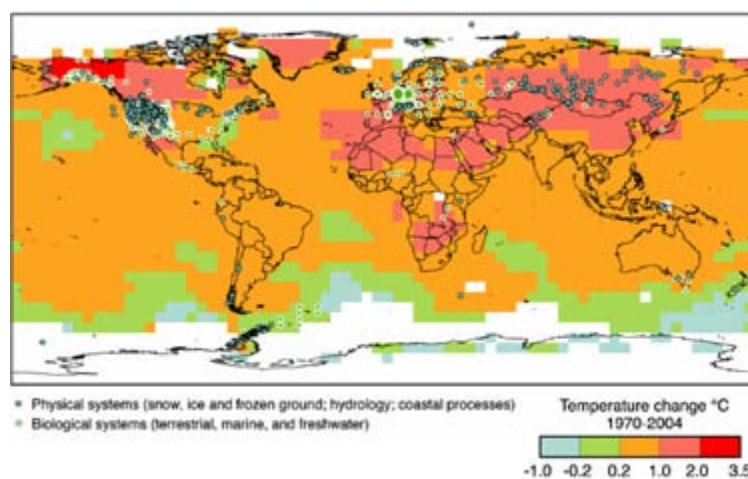
Climate Change and Investment Sectors

INTRODUCTION

Most investments are structured to perform optimally under a set of established conditions and assumptions, based on historical data and projections for the future. For those risks that may compromise return on investment, risk management measures are typically recommended through the investment appraisal process.

However, investment appraisals usually do not take into account the changes that may be caused directly or indirectly by a warmer climate. Climate change is underway and has already caused changes in environmental conditions. **Figure 1** shows where significant changes in temperatures and physical and biological systems have already been observed (IPCC WGII 2007). The blue and green dots indicate areas where observational studies have been undertaken. There is a lack of dots in many developing countries because studies have not been undertaken there—but not because changes are not occurring. Out of more than 29,000 observational data series, more than 89 percent are consistent with the direction of change expected as a response to climate warming. Investment appraisals that do not take serious consideration of these changes may result in significant underperformance or even failure of investments.

Figure 1. Observed Changes in Physical and Biological Systems, 1970–2004



Note: White areas indicate insufficient observational climate data to estimate a temperature trend.

Source: IPCC WGII 2007, p. 10

Part I of this report (provided as a separate document) discusses the risks that climate change poses to financial institutions through implications to credit risk, financial risk, strategic risk, operational risk and legal risk. This part of the report first reviews a range of cross-cutting risks that can affect the performance of many key investment sectors (**Section 1**). In **Section 2**, it provides additional evidence on climate-change risks for five climatically sensitive sectors (agribusiness; water; electric power; transport; and oil, gas and mining).

1. Cross-Cutting Risks
2. Water Availability

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Water is Essential to Many Key Investment Sectors

Sufficient water availability is essential for numerous investment sectors, including utilities, electric power, food and beverage, agribusiness, forestry, metals, oil, gas, and mining, pulp and paper, and chemicals.

Water is used to produce energy in hydropower plants and for cooling in thermal power plants. It is also essential in agricultural production and is a key resource used in many manufacturing and industrial processes for cooling, washing, or as a production input (e.g., in the oil, gas, and mining,

pulp and paper, and food and beverage sectors, as well as in other industrial production such as semiconductors; Morrison et al. 2009).

Many Investments are in Regions at Risk of Water Shortage Now or in the Future

Many of the regions in which developmental financial institutions invest in water-dependent sectors are already affected by water stress. For example, South Asia is already experiencing severe water stress (Figure 2), and some countries in the region will face greater problems with water availability because of

climate change (Figure 3). The Middle East, North Africa, and Sub-Saharan Africa are other regions already and increasingly vulnerable to problems with water availability due to climate change.

Figure 2. Areas Currently Vulnerable to Water Stress

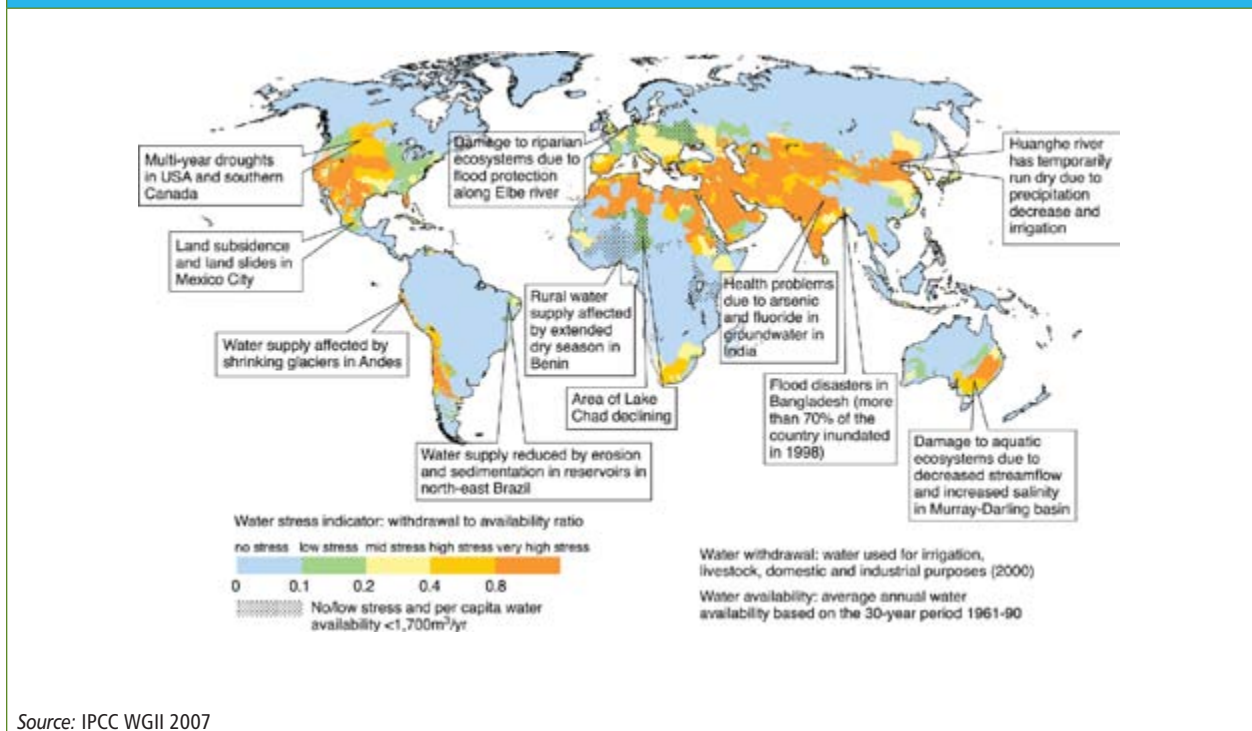
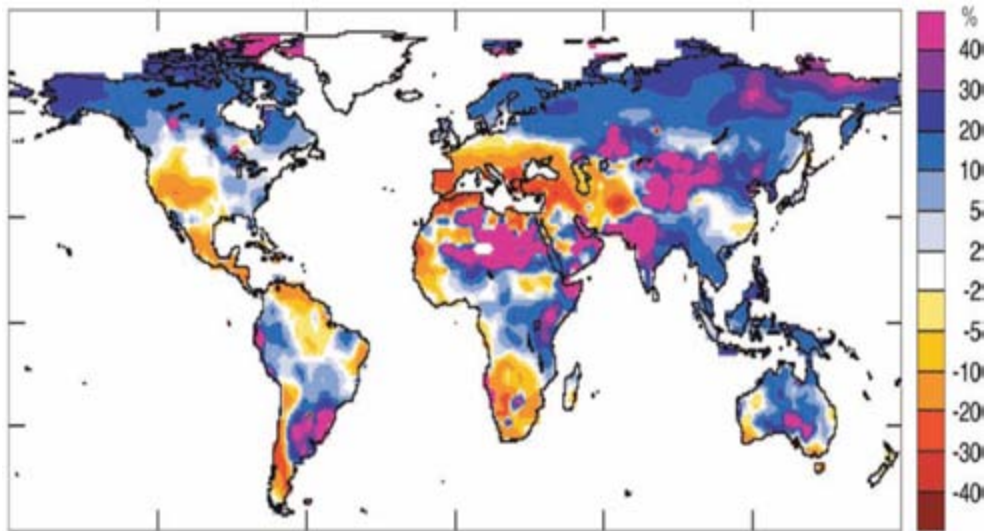


Figure 3. Percentage Change in Annual Runoff by the 2050s under the IPCC Emission Scenario A1B, Based on an Ensemble of 12 Climate-Change Models



Note: See Appendix. Greenhouse Gas Emissions Scenarios for details on the A1B emissions scenario.

Source: IPCC WGII 2007

Climate Change Will Impact Water Availability Through Various Channels

Water may become less available as a result of the following climatic changes:

- Seasonal changes in average rainfall
- Changes in the intensity and frequency of extreme (i.e., heavy) precipitation events
- Higher temperatures, causing increased water loss through more evaporation and more plant transpiration
- Changes in the timing and duration of snow, ice, and permafrost melt

- Sea-level rise and increased saline intrusion into sources of surface water and groundwater
- More frequent and intense drought and extended dry periods

These changes will affect the availability of groundwater and of surface-water runoff into rivers and lakes. In regions with little or no snowfall, changes in water runoff are more dependent on changes in rainfall than on changes in temperature. For regions fed by snow or glacier melting, higher temperatures will play a predominant role: in the short term, river flows may increase with earlier and more rapid snowmelt, but the contribution of snow and glacier melting will gradually decrease over the following decades.

In a warmer world with a bigger population, water demand will increase. Further, competition for already-scarce water resources may intensify, not only at the local level among individuals, but also between governments (see **Box 1**).

Box 1. Business Continuity at Risk as a Result of Increased Conflict between Governments on Access to Freshwater

The Indus Water Basin Treaty of 1960, mediated and signed by the World Bank, governs water rights and outlines steps to resolve water-related disputes between India and Pakistan.

Water issues have been a major sticking point between the two countries for the past half century, dating to conflicts in the late 1940s, when India reduced water flows to Pakistan to apply pressure on the government. Numerous Indian attempts to build dams in this basin—including the Baglihar Dam on the Chenab River in the mid-1990s—have inflamed the often tense political situation between India and Pakistan. Because 80 percent of Pakistan’s food needs are met domestically, reduced water availability can have significant implications for its food security and the health of its workforce. The pressures placed on this river basin by climate change will only serve to exacerbate this situation.

Climate-driven water scarcity is fuelling “river wars” in the Middle East and Africa. For example, nine countries of the Nile River Basin are in dispute over water sharing. Countries such as Uganda and Rwanda are attempting to overrule a 1959 treaty that restricts building on the river without Egypt’s consent, as the latter relies on the volume of river water it currently receives. Iraq and Syria oppose the building of dams on the Euphrates River by Turkey. The water levels on the Euphrates have been low for several years, leading to severe hydropower supply shortages. Palestine only has access to one-fifth of the water aquifer it shares with Israel along the West Bank.

Droughts in the southeastern United States in 2007 and 2008 prompted interstate battles for water resources. For example, two Georgia state legislators attempted to move the state’s borders into Tennessee in 2008 in order to gain access to the Tennessee River. In 2007, South Carolina sued North Carolina about a plan in the latter to withdraw large volumes of water from the Catawba River in the former. In mid-2008, Florida sued the U.S. Army Corps of Engineers over its plans to reduce water flows into the state.

Conflicts such as these could become more frequent as climate change increasingly threatens water supplies. In some regions water scarcity affects national security; this may present major consequences for business continuity.

Sources: Stoddard 2009; Morrison et al. 2009; Broder 2009

When overlaid with current water-scarcity issues and overall increased demand for water, these changes are already causing—and indeed will increasingly pose—challenges to some investment clients.

Water Shortages and Supply Disruptions Can Lead to Significant Business Costs

Reliance on freshwater resources can lead to substantial business losses in the current climate, and vulnerability is likely to worsen under a changing climate.

For example, droughts in the southeastern United States led to crop losses of more than \$1.3 billion in 2003 alone (Morrison et al. 2009). Climate change impacts on rainfall patterns and hydrology may disrupt the economies of countries that rely on the agriculture sector for at least 20 percent of their GDP by affecting primary-sector outputs (World Bank 2009b). As a result, investments in these countries may be affected by reduced national growth.

Investments in Water Under a Changing Climate Will Face Costs and Societal Challenges

Because populations and industries are already vulnerable to current water stresses, and because climate change will increase that vulnerability, investments in water supply, infrastructure, and treatment will be more costly as a result of climate-related impacts. In fact, estimates of CAPEX in the water sector of developing countries that do not take into account the impacts of climate change on infrastructure wear and tear (see **Section**) may undervalue costs.

In 2007 the UNFCCC estimated the cost of the additional infrastructure needed to meet future increased water demand (because of higher population and economic growth) and to manage the impacts of future climate change under two GHG emission scenarios (A1B and B1; see Appendix. Greenhouse Gas Emissions Scenarios) to be around \$8 and \$9 billion per year, respectively, in developing countries by 2030 (UNFCCC 2007). This has been criticized as possibly underestimating the costs of climate change on water supply infrastructure (Parry et al. 2009).

Further, the Millennium Development Goal of “halving by 2015 the number of people without sustainable access to safe drinking water and basic sanitation” may be compromised under a changing climate, as the number of people without access to safe drinking water or sanitation is set to increase (see **Table 1**).

Table 1. Additional Number of People Living in Water-Stressed Basins because of the Combined Impacts of Climate Change and Population Growth by the 2050s (Compared to 1995)

Greenhouse gas emissions scenario	Range of estimated additional millions of people
A2	2,983–5,319
B2	1,398–3,565

Note: Water-stressed basins are characterized by renewable water resources of less than 1,000 m³/year per capita.
 Source: IPCC WGII 2007

WATER QUALITY, POLLUTION CONTROL, AND DISCHARGES

Some sectors require significant water inputs or high water quality, and some are also subject to strong standards for water discharge quality. The oil and gas, mining, agriculture and forestry, and pulp and paper sectors are some significant examples.

Climate Change May Alter Pollutant Pathways

Reduced river flow (as a result of higher temperatures causing more evaporation and changing rain- and snowfall patterns) may lower the capacity of rivers and lakes to dilute pollutants.

Freshwater quality is also generally degraded by higher water temperatures, which alter the rate of biogeochemical processes and, most important, lower the dissolved oxygen concentration of water.

More frequent and intense heavy rains and floods (especially after prolonged dry periods) may increase pollutant runoff from land, property, or equipment into surface water and groundwater sources. Heavier precipitation and flooding can also erode stream beds and banks, leading to increased sedimentation and decreased quality of receiving water bodies.

Water and Wastewater Treatment Infrastructure may be Inadequate in a Changing Climate

If the chemical composition, temperature, and sunlight exposure of water environments change, the capacity of freshwater bodies to naturally process and purify water may be affected—for example, because of modified rates of decay of certain pollutants.

Water drainage systems and wastewater treatment facilities can be overwhelmed during extreme rainfall events, possibly leading to pollutant leakage into freshwater sources.

Indirect Impacts of Decreased Water Quality may have Business Consequences

Waterborne diseases may also become more prevalent as a result of reduced freshwater quality; this could affect workers or the communities surrounding businesses. Climate change–driven changes in freshwater quality can in turn affect the health of freshwater ecosystems. For example, the combination of increasing temperatures, higher water pollution, and decreased river flows may spur algal growth, harming ecosystems upon which populations and businesses depend.

Degraded Water Quality has Business Costs

Some businesses that rely on extremely clean water may see their OPEX increase if climate change induces lower water quality. The probability of business interruptions because of low water quality may increase.

Similarly, the costs of complying with laws or regulations on discharge quality may be higher because of increased requirements for water cooling or treatment. Water-intensive and polluting businesses, such as energy companies that use fossil fuels and pulp and paper producers, are often required to cool down and/or treat used water before discharging it. The requirements may come from national or local legal or regulatory standards or contractual agreements. These businesses may need to step up their environmental monitoring and potentially install additional effluent-treatment facilities to ensure their management of water pollution and compliance with water-quality requirements.

Companies will be increasingly scrutinized for their practices and safeguards to manage and maintain water quality as climate change increases risks of pollution.

ENERGY RELIABILITY AND SECURITY

Many business sectors are dependent on secure and reliable energy supplies.

Climate Change may Increase the Probability of Energy Supply Interruptions

Energy companies are very vulnerable to climate change impacts (see **Sections 15 and 17**):

- They typically rely on long-lived, capital-intensive assets sensitive to ambient climatic conditions for their efficiency.
- They often have significant freshwater requirements for extracting or cooling (or for generating electricity, in the case of hydropower).
- They are vulnerable to changes in demand patterns and price volatility, which are related to climatic factors.

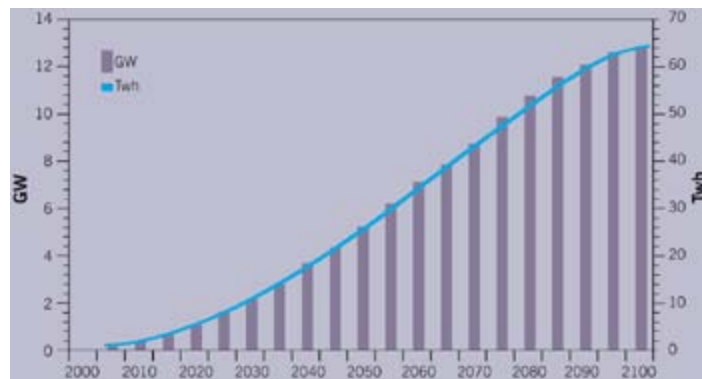
Future increases in demand for energy as a result of climate change may further increase energy supply interruptions.

In India alone, the additional power generation needed due to climate change is expected to be approximately 1.0 GW by 2020 (see **Figure 4**; IIM 2005). The increase will be needed to cover additional needs for cooling and for energy to pump groundwater, as irrigation demands grow. Economic growth scenarios project that total power generation capacity in India will increase from 96 GW to 912 GW between 1995 and 2100. It is estimated that climate change impacts will increase power capacity requirements by 1.5 percent (IIM 2005).

Energy Supply Interruptions have Serious Consequences for Businesses

In most sectors, energy supply interruptions translate into revenue losses. As climate change affects energy production, transmission, distribution, supply, and demand, these financial losses may increase if climate risks are left unmanaged.

Figure 4. Additional Power Capacity and Power Generation Requirements in India Due to Climate Change



Source: IIM 2005

ASSET DESIGN, PERFORMANCE, AND INTEGRITY

Assets Designed without Taking into Account Future Changes in Climatic Conditions may see Their Useful Lives Reduced

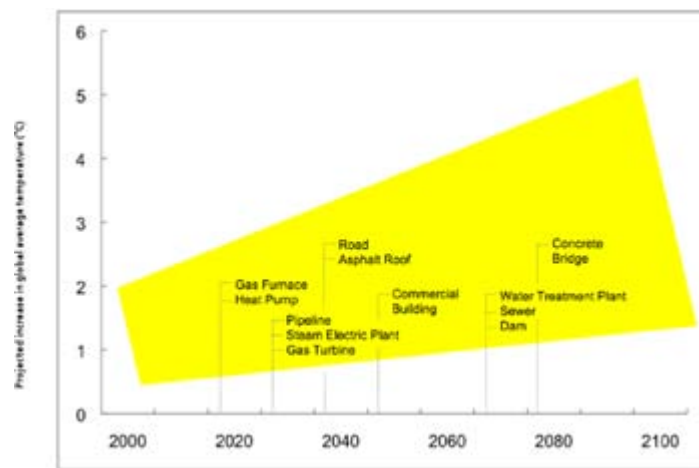
Higher temperatures, changes in rainfall patterns, and more intense and frequent extreme weather events (e.g., droughts, heavy rain- or snowfall, floods, dry spells, and tropical cyclones and storms) will increasingly damage assets that were not designed to cope with changing climatic conditions. Normal asset wear and tear is also likely to increase, with higher repair and maintenance requirements.

Coastal assets may be vulnerable to damage from sea-level rise, as the contribution of the melting of the Arctic and West Antarctica ice sheets and of glaciers and ice caps to sea-level rise accelerates (Cazenave et al. 2008; Hare 2009; Rahmstorf et al. 2007; Rahmstorf 2007). They may also be at risk from increased erosion due to changes in tides and wave heights.

Climate change impacts may contribute to the reduction of assets' useful lives. This could be particularly disruptive

for sectors that depend on large fixed assets with extensive lead times for design and construction and long lifetimes (see **Figure 5**; Ruth, Davidsdottir, and Amato 2004). For example, concrete bridges built today (with useful lives up to the 2080s) may have to withstand a temperature increase between approximately 1°C and 4.5°C.

Figure 5. Examples of Assets' Lifetimes and Projected Temperature Increases up to the 2080s



Note: Projected range of temperature increases, compared to 1961–90, are shown by the yellow band.

Source: IPCC WGII 2007

Infrastructure Investments May be Most at Risk of Damage to Assets

Climate change is likely to have substantial consequences for the integrity, performance, lifetime, and design criteria for most of the world's infrastructure, including water supply, sanitation, flood control, hydropower, and coastal development and defense assets.

Flood risk can increase due to sea-level rise, increased river or groundwater levels, or heavy precipitation that overwhelms drainage systems. Coastal infrastructure assets are particularly vulnerable. In coastal and estuarine locations, rising sea levels may present a significant challenge to flood-risk management, especially where land levels are subsiding. Most coastal flood defenses have not yet been upgraded to take account of climate change, so the standards of protection they offer are eroding over time. Land, property, and infrastructure on the coast may also be subject to increased rates of coastal erosion, due to sea-level rise and increased storm surges. The additional costs needed to protect coastal infrastructure in non-OECD countries against sea-level rise in 2030 is estimated to be \$2.5 billion (UNFCCC 2007).

Asset, Equipment, or Staff Efficiency may be Reduced Under Changing Climatic Conditions

Increased temperatures can affect asset efficiency, particularly for any equipment that gives off heat. Other climate-related risks, such as increasingly frequent and more intense extreme weather events may also hamper asset efficiency or operations continuity. For the period 1951–2006, the UNFCCC (2007) estimated the average annual losses for infrastructure alone due to “great weather disasters” (e.g., cyclones, droughts, and floods) at \$21.1–\$87.7 billion.

More frequent and intense warm spells and heat waves will increase thermal discomfort and risks of heat stress in buildings without adequate cooling capacity. Energy use in buildings will also be affected by temperature changes. Increased demand for cooling during heat waves may increase energy consumption and cause power failures in local transmission grids due to excessive loads. This may compromise clients' ability to reduce their GHG emissions.

In 2030, it is estimated that \$153–\$650 billion of infrastructure will be vulnerable to climate change.

^a Assuming that climate change adaptation requires a 5–20 percent increase in capital costs, the adaptation costs would be \$8–\$130 billion per year in 2030 (based on two sets of data on current climate-related losses; UNFCCC 2007).

Investments in sectors reliant on large fixed assets could be similarly affected by climate change losses. The oil, gas, and mining sector and the Latin American and Caribbean region are particularly vulnerable to climate change.

^a A survey conducted by Lloyd's and the Economist Intelligence Unit in 2008 revealed that company directors are concerned about emerging environmental liabilities in the context of climate change and increased scrutiny of corporate environmental performance (Lloyd's and EIU 2008).

RAW MATERIALS, TRANSPORT, SUPPLY CHAINS, AND LOGISTICS

Supply Chains may Hide Indirect Climate Risks

Industries that rely on long supply chains and distribution networks may be indirectly exposed to climate change impacts through their suppliers and/or distributors. Climate-related risks include transport delays and interruptions, logistics and supply failures, and commodity price vulnerability, as a result of extreme weather events such as heat waves, droughts, heavy rainfall, storm surges, and flooding. Higher temperatures and changing rainfall patterns may also affect the supply of climatically dependent inputs (such as agricultural commodities). Sea-level rise and sea storm surges may damage coastal trade assets or operations.

Transport Infrastructure and Operations are Sensitive to Climate

All forms of transport investments will face climate-change risks. High peak temperatures can buckle rails and damage roads, and can also affect air transportation. Droughts and low-flow events may disrupt transport on inland waterways. Transport infrastructure is vulnerable to damage from heavy rains and flooding. Cyclones and storms may close ports or shipping routes.

Climate-related disruption to transportation networks will also increase production costs and potentially harm investments that are heavily transport-reliant. This is especially the case for ports and other water-related transportation systems,

as 90 percent of world trade by volume and 70 percent by value occurred via seaborne cargo in 2000 (Tamiotti et al. 2009).

Some industries, such as nonmetallic mineral products, industrial and consumer products, and wholesale and retail trade, that rely upon secure sources of raw materials or manufactured products, as well as reliable supply chains, transportation linkages, and logistics to produce, sell, and distribute their goods, will be particularly vulnerable to climate-related disruptions to transport infrastructure.

Box 2. Examples of Business Supply and Transport Disruption in China Due to Climatic Conditions

China's major economic and transport hub on the Pearl River Delta—where the transportation, storage, post, and telecommunications sector recorded output of \$14.32 billion in 2003—is particularly vulnerable to climate change, as its current vulnerability to sea-level rise and flooding will be exacerbated by climate change.

In 2006, flooding cut the main rail line between Guangzhou and Beijing, stranding thousands of passengers and causing significant delay to rail travel. Later the same year, heavy rains caused wiring problems, severely disrupting rail services in Hong Kong. In fact, flood-related disasters caused direct economic losses of \$2.5 billion in 2006 in Guangdong Province, where this transportation hub is located.

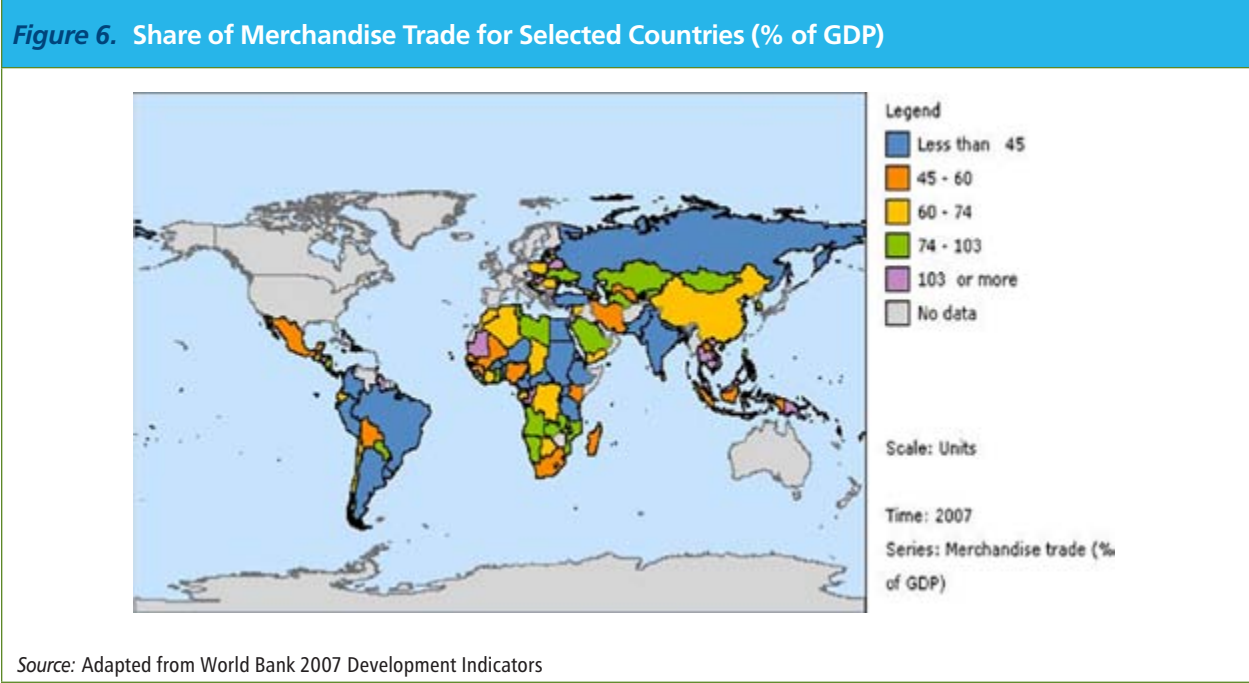
Flooding in 2007 and severe snowstorms in 2008 damaged mines owned by Hong Kong-based electric utility CLP Holdings. As a result, its facilities were forced to shut down for repairs or reduce energy production because of the lack of coal. Although production was resumed, it took several weeks before CLP's facilities were restored to normal operations.

Sources: CLP Holdings' response to the CDP 2008 questionnaire; Tracy et al. 2006

Countries that depend heavily on trade in turn depend on reliable transportation. **Figure 6** shows

those countries that rely on trade for more than 75 percent of their GDP (highlighted in green and purple)

and could potentially suffer the most economically from climate change impacts on transportation.



Industrial Inputs may Become Less Reliable Because of Climate Change Impacts

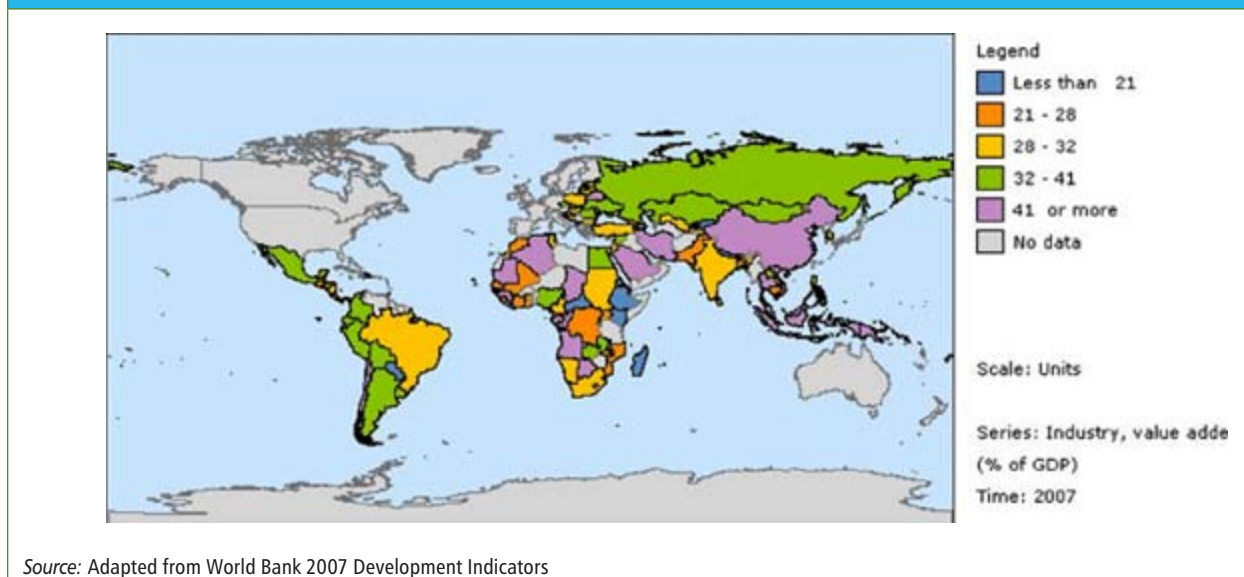
Higher temperatures, changing patterns of rainfall, and the resulting impacts on pests, diseases, and competing crops all mean that agricultural raw materials may no longer be economically viable in current locations under future climate conditions. Commodities that remain available may be of reduced quality. Incremental changes in climate and extreme weather events can also reduce the efficiency of and cause damage to equipment, facilities, and

infrastructure that extract, store, and transport natural resources to industrial centers.

For example, thawing permafrost can cause ground instability and decrease production in the oil, gas, and mining sector, which supplies essential inputs to many industrial operations. As petroleum accounts for 95 percent of the total energy used by world transport (Tamiotti et al. 2009), any disruption in the availability of oil products will result in price increases across sectors, with particularly significant consequences for sectors that rely on transportation and trade.

If climate change disrupts the flow of raw materials to businesses in countries that derive at least one-third of their GDP from industry, then the national economic impact could be significant, with implications for investments in these countries (see **Figure 7**).

Figure 7. Share of Industry Value Added (or net output) as % of GDP for Selected Countries



SITE AND GROUND CONDITIONS

Site Conditions of Some Investments will be Affected by Climate Change, with Potentially Significant Cost Implications

Site conditions and ground stability are directly affected by temperature, precipitation, and high winds and waves. Many businesses do not consider the combined effect that climate change and land movements, including subsidence, heave, erosion, and landslides, can have on their assets.

For example, longer and hotter summers can dry out clay soils and cause them to shrink, making buildings and network infrastructure (such as roads and service pipes) vulnerable to cracking and other damage. Increased sea-level rise and higher waves may aggravate land erosion. Heavier rainfall and more frequent and/or extreme storm events may cause accelerated erosion or more frequent landslides.

Flooding, whether coastal, riverine, or caused by runoff following intense precipitation events (flash flooding), is perhaps the most significant climate-related site and ground condition risk.

Melting permafrost is also a significant climate-related risk to investments in polar regions. Natural gas and oil pipelines, dwellings, roads, and other valuable assets and infrastructure depend on permafrost to provide stability for their foundations. These assets are at risk of substantial damage due to permafrost instability and melting (see **Box 3** on evidence for extensive permafrost retreat that has already taken place).

Climate-related changes in site and ground conditions may disrupt operations and create revenue losses. They may also require expenditures to restore sites or to adapt to new sites or ground conditions.

Box 3. Dramatic Permafrost Retreat Found in Northern Canada

A study published in early 2010 found that the permafrost border in the James Bay region of Canada has receded north by 130 kilometers over the past 50 years.

James Bay extends south from Hudson Bay and borders the provinces of Ontario and Quebec. The researchers measured the retreat of the permafrost border in the region by looking for palsas (distinctive mounds that form naturally over ice in the soil) in seven peat bogs located between the 51st and 53rd parallels. Aerial photos taken in 1957 showed palsas present in all seven bogs; a survey taken in 2004 found palsas in only two. A follow-up assessment in 2005 found that the number of palsas in these two bogs had further decreased over the course of only one year by 86 percent and 90 percent, respectively.

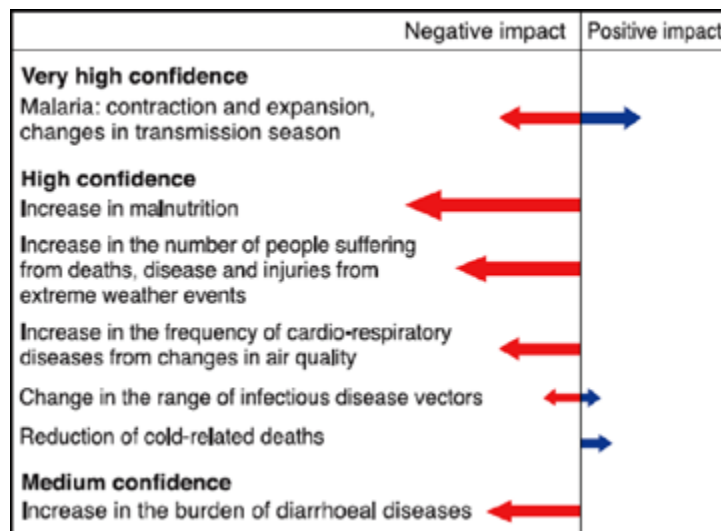
If the trend continues, according to the authors of the study, permafrost in the region will completely disappear in the near future. The most probable explanation for the loss of permafrost is climate change, though a lack of long-term climatic data for the area prevents official confirmation of this judgment. However, one of the authors noted that the average temperature of the northern sites he has studied for over 20 years has increased by 2°C over that period.

Source: ScienceDaily 2010

HUMAN HEALTH AND SAFETY

Climate change will affect the health of the human capital upon which businesses rely, including staff, labor pools, subcontractors, and commercial partners (see **Figure 8**). This will translate into costs for investments through lower productivity, workers' compensation claims and disputes, or business interruption.

Figure 8. Projected Direction and Magnitude of Change of Selected Health Issues Due to Climate Change, by Level of Certainty

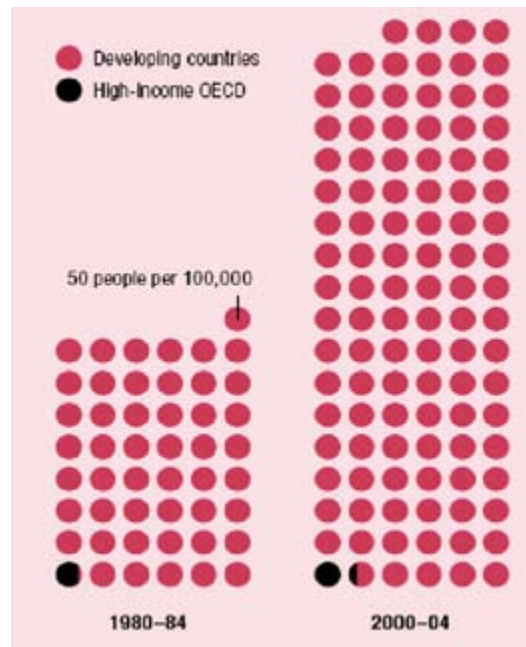


Source: IPCC WGII 2007

Increased Number of Deaths or Injuries Caused by Extreme Weather Events

The risk of being affected by a natural disaster (such as droughts, floods and storm events) in developing countries has increased significantly in the past 20 years (see **Figure 9**).

Figure 9. Risk of Being Affected by a Natural Disaster per 100,000 People



Source: UNDP 2007

Under a changing climate, risk of death, disease, or injury from heat waves, floods, storms, fires, and droughts for project personnel and those who travel to visit projects will increase. These occupational risks will affect both indoor and outdoor workers. The safety and performance of buildings, structures, and other assets that may not be climate-resilient could also translate into increased costs to ensure worker safety, comfort, and productivity (Bray et al. 2007).

For example, warmer working conditions are a concern for both health and the ability to perform work tasks. They can lead to diminished mental task ability, increased accident risk and, if prolonged, heat exhaustion or heat stroke. These can significantly affect the productivity of outdoor, production-line, and factory workers. In order to reduce impacts, maximum workplace temperatures could be introduced or become more widespread.

Altered Disease Distribution

Changes in climate have already altered the distribution of some infectious disease vectors, as well as the seasonal distribution of some allergenic pollen species. Climate change projections show that the range of some infectious diseases will continue to change, which could mean that the locations of some investments without current major health hazards may be exposed in the future.

The distribution, intensity, and seasonality of meningitis has been strongly linked to climatic and environmental factors, especially drought. For example, it has recently expanded in West Africa because of land-use changes and regional climate change.

Diseases transmitted by parasites such as ticks will continue to shift in their distribution range. Similarly, diseases transmitted by rodents may increase during periods of heavy rainfall or flooding because of altered patterns of human-pathogen-rodent contact (IPCC WGII 2007).

Climate change will have a mixed impact on malaria: in certain places the geographical range of the disease will contract, while in others it will expand and the transmission season may change. This is because, on one hand,

decreased rainfall is a limiting factor for mosquito populations, while on the other hand, increased temperature—especially at the start of the transmission season—has a positive impact on malaria transmission.

The population at risk from dengue fever is expected to increase by 5–6 billion people by 2085, as regions with a suitable climate for dengue transmission will expand (Hales et al. 2002).

Food and Water Safety may be Increasingly Compromised

Food and drinking-water safety may be compromised by warmer temperatures and changing patterns of precipitation, with consequent risks of contamination and food poisoning.

Increased risk of water and land contamination with chemicals, heavy metals, or other hazardous substances because of intense downpours, flooding, or storms may also add to occupational health and safety risks.

Increasing demand for freshwater resources, combined with reduced supply during hot and dry seasons may also lead to higher rates of malnourishment, affecting businesses' labor supplies.

The Burden of Diarrheal and Cardiorespiratory Diseases may Increase in Developing Countries

In many countries where developmental financial institutions are active, sanitation infrastructure is poor and flood events are often followed by increased rates of diarrheal diseases (IPCC WGII 2007). In the most extreme cases, flood-related increases in cholera and typhoid fever have been reported.

Climate-induced degradation of air quality (see **Section 11**) and impacts on the seasonality, length, and load of pollen may aggravate respiratory conditions and allergenic diseases. For example, climate change has already caused an earlier onset of the spring pollen season in the Northern Hemisphere, and the abundance of a few species of airborne pollens has increased due to climate change (IPCC WGII 2007).

Health Impacts and Losses of Life have an Economic Cost, which can Affect Some Investment Policies and Projects

Overall, the worldwide economic value of loss of life due to climate change ranges between \$6 billion and \$88 billion, as climate change claimed 150,000 lives and led to losses of 5.5 million disability-adjusted life years (DALYs; one DALY is one year of life

lost due to either increased mortality or prevalence of disease) in 2000 alone (IPCC WGII 2007). These figures are expected to increase as climate change impacts become more prevalent and severe.

IDA and conflict-stressed countries are particularly vulnerable to increased prevalence of diseases such as malaria and dengue fever, greater food and water insecurity, and more injuries and deaths due to extreme weather events.

For instance, heavy precipitation events in tropical and sub-Saharan Africa frequently lead to outbreaks of diarrheal diseases and contamination of groundwater and surface water supplies. Increased human health problems may increase business costs there and threaten development improvements.

MARKETS

Demand in Some Investment Markets is Sensitive to Climate Conditions

Weather and climate play a significant role in affecting consumer preferences. People tend to consume different kinds of products in different weather conditions and in different seasons. For example, higher temperatures will affect demand for energy, as the need for heating decreases in winters while the need for cooling increases in summers. Although the actual impact of this demand shift will vary depending on the region and the season, in general the increase in cooling is expected to more than offset the decrease in heating (IPCC WGII 2007).

Peak demand levels will also increase, in response to higher peak temperatures, potentially forcing energy producers to build expensive peak-load plants or to buy energy on the open market at a high cost. Decreased heating demand in winters may damage natural gas companies' bottom lines.

Investments in energy production, distribution, and supply may need to deal with important shifts in consumer demand due to changing climate conditions, with consequences for income. Investments in water resources and agricultural raw materials (or in businesses that depend on a consistent supply of energy, water, or agricultural inputs) are likely to be affected by changing patterns of consumer demand as a result of a changing climate.

Climate Change may have Impacts on Macroeconomic Factors that Determine Investment Returns

Direct climate change impacts in one industry may create a ripple effect of resulting impacts on other industries, particularly those with global markets or long and complex supply chains. Climate impacts on the energy, agribusiness, oil, gas, mining, forestry, and other nonmanufacturing industries with large fixed assets (such as metals production) may affect the prices of the commodities they supply to other sectors.

For example, as will be discussed further in **Section 13**, climate change can affect crop supply and quality. Coupled with higher demand due to population growth and increasing affluence, these impacts could trigger sharp food price increases, with financial consequences for food-processing industries. Investments in food-processing industries may see their market position change significantly, as climate-related impacts on agricultural output affect commodity prices (see **Box 4**).

Additionally, climate-related commodity price changes may have an effect on foreign exchange rates for countries that rely on foreign trade in commodities for a large portion of their GDP (see **Section**). Investments denominated in currencies other than U.S. dollars may then be exposed to increased exchange-rate risk.

COMMUNITIES

Climate Change will Disproportionately Affect Impoverished Communities and Affect the Relationship Between Communities and Investments

- Climate change may result in the following impacts for communities near investments:
- Decreased availability and/or quality of freshwater resources

Some Markets will Contract as the Climate Changes, but there will Undoubtedly be New Opportunities

The spread of vector-borne diseases such as malaria, dengue fever, and diarrheal diseases will increase demand for vaccines, medication, and other products and services from the pharmaceutical industry.

Engineering firms could also see increased revenues from designing, building, and operating assets and infrastructure that are more climate-resilient and energy-efficient and that utilize renewable-energy resources.

Box 4. Implications of Climate-Related Changes in Agricultural Outputs for Trading Markets

India is one of the world's largest producers and consumers of sugar. Droughts in 2009 caused a sharp reduction (44 percent) in Indian sugar output projections for the end of the year. As a result, sugar prices hit a three-year high in early August 2009 on the New York Stock Exchange, while also reaching their highest levels in 28 years on the London Stock Exchange.

Overall, sugar prices rose by 64 percent in 2009 on the expectation that India would become a net importer for two years in a row.

Sources: Lesova 2009; Mukherjee 2009

- Decreased output of certain livelihood activities including agriculture and fishing
- Higher incidence of disease and health problems
- Increased risk of death or injury because of extreme weather events

As a result, community livelihoods may come under more stress or even, in some cases, be threatened. Surrounding businesses may be seen as contributing to the deterioration of community welfare, and may be

criticized or opposed (see **Box 5**). This can compromise the efforts of investment clients to manage their relationship with communities.

In short, climate change can make it more difficult for investments to operate by exacerbating existing tensions or creating new sources of tension between projects and communities and/or projects and governments over access to, and quality of, land, water, and energy resources.

Businesses that do not Consider the Climate-change Adaptation Actions that Communities Undertake on their Own may Fail in Managing Community Relationships

Water scarcity already creates tensions around many investments. In the future, these tensions may be more acute because of climate change impacts on communities and increased use of water by communities. For example, farmers who have historically relied on rain-fed agriculture may increasingly have to use surface water and groundwater sources to irrigate their crops because of changing patterns of rainfall. As a result, companies operating in the area may face increased competition for water resources and possibly more intense criticism of their own water use and water management.

Box 5. Coca-Cola's Relationship with Water-Scarce Indian Communities

The Energy and Resources Institute, a leading Delhi-based environmental research group, published a report in early 2008 calling on Coca-Cola to consider shutting down one of its bottling plants in drought-stricken Rajasthan, India, saying the plant was depleting already-scarce water supplies for nearby villages.

The report looked at six of Coca-Cola's 49 bottling plants in India and highlighted specific conditions at the Kaladera plant in Rajasthan. It concluded that the plant's presence in this area would "continue to be one of the contributors to a worsening water situation and a source of stress to the communities around" and that the company should find alternative water supplies, relocate, or shut down the plant.

The chief executive of Coca-Cola's India division, Atul Singh, said the company would not close down the plant. "The easiest thing would be to shut down, but the solution is not to run away. If we shut down, Rajasthan is still going to have a water problem. ... We want to work with farming communities and industries to reduce the amount of water used."

The report is among the latest in a series of controversies around Coca-Cola's use of water in its operations. All over India, problems of water shortages and community conflict have emerged around many of Coca-Cola's bottling plants. Discontented communities have networked with regional, national, and international organizations fighting for human rights to water. As a result, universities in the United States and in the United Kingdom have canceled contracts for exclusive sales of Coca-Cola-brand products.

In a pledge to regain its social license to operate, Coca-Cola has engaged in various activities around water conservation.

Sources: Drew 2008; Brown 2003; Srivastava 2003

Climate change may also increase demand for food crops. In areas suffering from drought, higher temperatures, and the presence of new pests and diseases, this pressure will exacerbate tensions between agribusiness investments and small-scale and subsistence farmers.

Community conflict and violence may increase, and increased risk of damaging complaints, disputes, and protests may create a more challenging operating environment for businesses (Acclimatise and Synergy 2009).

These risks can translate into real losses for companies. Climate-related adverse impacts on the relationships between companies and their surrounding communities may subsequently affect the companies' reputation and brand value, which may result in indirect financial losses.

Taking Account of Local Community Needs When Identifying Climate-related business-risk Management Actions may Bring Benefits

Climate-risk management measures undertaken by a project to protect its income or asset value may also help to improve the capacity of surrounding communities to adapt to climate change risks. For instance, a more stable investment climate and a healthier workforce may be ensured by switching to alternative and unexploited sources of water (Acclimatise and Synergy 2008). Businesses that work with communities can often increase the effectiveness of their own adaptation actions (see **Box 6**).

Furthermore, the opportunities to manage community risks with consideration for climate change impacts may not be instantly apparent, but when identified and harnessed they can lead to enhanced reputation and brand value, a healthier workforce, decreased community vulnerability, and better knowledge of local conditions and climatic changes.

The UNFCCC (2007) estimates that the investment required in climate change adaptation in developing countries could approach \$90 billion by 2030. If that investment need is not met, community impacts could be very significant.

Box 6. Managing Business Impacts of Malaria

BHP Billiton's Mozal aluminum smelter project in southern Mozambique was suffering from high employee absenteeism, low staff morale, and subsequent productivity losses due to malaria. Mozal became an unattractive destination for skilled employees.

BHP Billiton realized that it needed to work with the community, government officials, and local organizations to implement a broad malaria strategy, rather than limiting its efforts to on-site action. Through its membership in the Lubombo Spatial Development Initiative (LSDI), BHP Billiton implemented an effective malaria-control program in the area around its Mozal operations.

As a result, it saw cases of malaria decrease by 70 percent, fatalities drop by 97 percent, absenteeism nearly erased, and productivity increased.

Source: "Medicines for Malaria Venture Aims to Develop Effective, Affordable Anti-malarial Drugs," on the BHP Billiton Web site, <http://sustainability.bhpbilliton.com/2004/repository/caseStudies/health2.asp> (accessed September 22, 2009).

AIR EMISSIONS AND SOLID WASTE MANAGEMENT

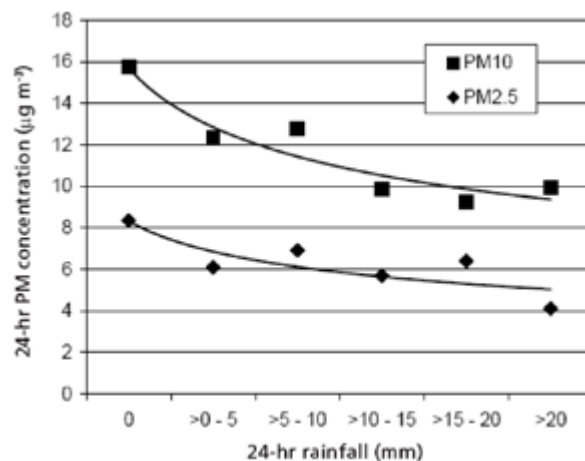
Climate Change Impacts on Ambient Air Quality might Affect Investments

It is likely that climate change will have the following impacts on air quality:

- Change in circulation of air pollutants (through changes in wind patterns and exchanges between the stratosphere and the troposphere)
- Transformation of pollutants (which is dependent on factors such as humidity, cloud cover, temperature, and albedo, all of which are sensitive to climatic conditions)
- Removal of pollutants (through changes in precipitation frequency and amounts)
- Emissions of pollutants (with changes in seasonal emission patterns because of the relationship between temperature and energy use)

For example, changes in precipitation can affect the levels of concentration of ambient particulate matter (such as dust), because rain plays a major role in scrubbing particulate matter out of the atmosphere (see **Figure 10**). Drought conditions (as well as extended dry periods coupled with sufficiently strong surface winds) can bring on an increase in surface dust and other particulate matter.

Figure 10. Relationship between Daily Rainfall and Average Daily Concentration of Particulate Matter (as measured in London)



Source: Defra 2007

Higher temperatures may also result in increased ozone production (**Figure 11**). Ground-level ozone is an air pollutant with harmful effects for humans and animals; it can also interfere

with photosynthesis. It is formed by the reaction of sunlight with air containing hydrocarbons and is a component of smog. At the same time, changes in cloudiness will affect ozone concentrations because of their impact on hours of sunshine.

Other climate-related impacts on atmospheric volatile organic compounds (VOCs) may come from increased evaporative emissions of petrol vapor caused by higher temperatures. VOCs are chemical compounds that can evaporate to or vaporize into the atmosphere. They include most modern industrial chemicals such as fuels, solvents, and refrigerants. Depending on the specific chemical concerned, they may be harmful to human health. Emissions of VOCs from vegetation will also increase as temperatures and sunlight exposure increase.

Climate change can also have indirect effects on air quality. Because energy consumption itself is influenced by climate, the GHG and other pollutant emissions of an investment may increase as more cooling is required and equipment efficiency decreases.

As a result, climate change may affect the frequency and intensity of episodes of poor air quality. This may result in pollution-management disputes between investments and people suffering from air pollution; there may be an increase in sick days for employees during episodes of poor air quality; or there may be enhanced regulatory control or higher risks of noncompliance with air-emission controls.

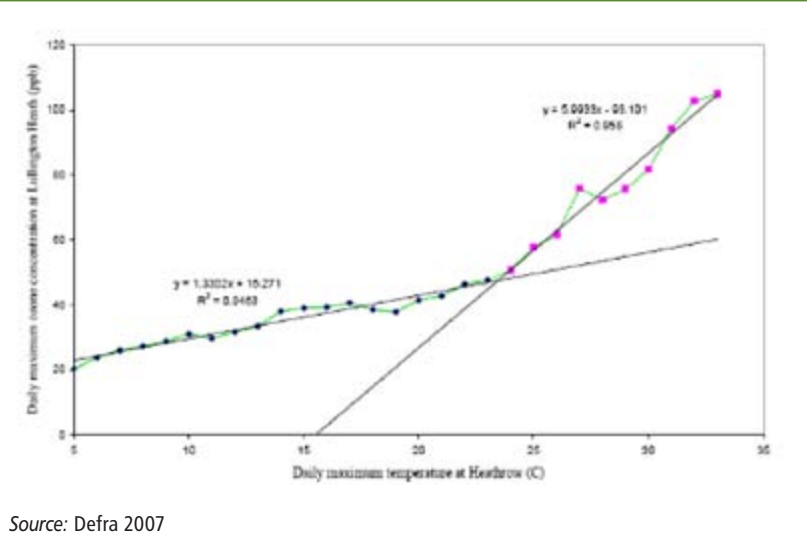
Solid-waste-Management Facilities may not Cope with Changes in Climate and may cause Damage

Industrial investments can produce solid waste, which may be managed and disposed of on-site or transported for off-site treatment and disposal at waste-processing and landfill facilities. These facilities are vulnerable to climate risks.

Landfill sites can be biologically “active” for more than 100 years, and timescales can be even longer for hazardous waste landfills. Once they have been constructed and filled, there is limited potential to adapt these sites to changing climatic conditions (U.K. Environment Agency 2008). These long-lived sites are most vulnerable to leachate (the liquid that drains from landfills) and the integrity of landfill liners, the impermeable barriers laid down under landfill sites that retard the migration of leachate into underlying aquifers or nearby rivers until they deteriorate.

For example, shifts in site hydrology and temperature can affect landfill degradation rates and leachate production and composition. Clay liners are vulnerable to subsidence and heave due to changing ground conditions (including rapid wetting of soils due to heavy rainfall after prolonged dry periods). Heavy rainfall and increased flooding may increase risks of off-site contamination.

Figure 11. Correlation of Daily Maximum Temperature and Daily Maximum Concentration of Ozone (as measured in London)



Source: Defra 2007

Furthermore, increased site disamenity from odor, vermin, and dust could lead to disputes against and/or reputational damage to investments. Extreme weather events could disrupt the road or rail transportation networks necessary for waste management (e.g., landfills may become inaccessible due to excess mud, flooding, or heavy precipitation).

Waste management facilities could face higher CAPEX or OPEX and legal disputes in case of damage that results from a failure in waste-management processes, if climate change impacts are left unaddressed.

ECOSYSTEM SERVICES

Ecosystems Provide Services that Support Some Investments with Significant, Though Often Unrecognized, Economic Benefits

Ecosystem services are the direct and indirect benefits that people and businesses obtain from ecosystems (MEA 2005). They are often categorized into four types:

- Provisioning services (e.g., supply of food, water, timber, and fiber)
- Regulating services (e.g., regulation of climate, floods, disease, waste, and water quality)
- Cultural services (e.g., recreational, aesthetic, and spiritual amenities)
- Supporting services (e.g., soil formation, photosynthesis, and nutrient cycling)

A recent study estimates that the costs of protecting ecosystems and the services they provide to human society from climate change could be over \$350 billion (Parry et al. 2009).

In some cases, ecosystems provide significant services to investments. Furthermore, some ecosystem services may be valuable because they can help provide resilience against the impacts of climate change. However, the economic benefits of ecosystem services to investments may not be recognized or valued, as they are often taken for granted and are not marketed goods.

Climate Change Impacts on Ecosystem Services may have Severe Business Implications for Investments

The various species within an ecosystem will respond differently to climate-driven environmental change, so that established equilibria between species may not be maintained. For example, the balance between predators and their prey, or parasites and their hosts, may change under different climatic conditions, with unforeseen consequences.

Some ecosystem services are sensitive to changes in climatic conditions, and their failure may translate into losses for some investments (see Error! Reference source not found. and **Box 8**).

Box 7. Success and Climate Resilience of Investments May Rely upon Ecosystem Services

Forests for pest control and protection against soil erosion

The presence of natural forest is associated with the presence of high bird and butterfly diversity. Insectivorous birds play an important role in protecting crops and plantations around forests from insect pests, thus performing a regulating ecosystem service. Forests may therefore have a positive impact on crop yield. A study on the effect of a bird enclosure on oil palm seedlings in Malaysia revealed that removing bird predators from plantations could lead to damage to approximately 28 percent of the plantation's foliage and, in turn, to fruit-yield losses. In a changing climate, the distribution of pests may shift so that the regulating function of natural forests against pests may become more critical to the success of agribusiness investments.

Furthermore, forests reduce soil erosion, as they protect the soil from rain. In doing so, they prevent the loss of important nutrients for tree, plant, and crop growth. If episodes of heavy rainfall, especially after a prolonged drought, become more frequent and intense (as is expected due to climate change), the risk of accelerated soil erosion may increase and the natural protection of forests may become even more valuable.

Watersheds for river-flow regulation

Forests in the watersheds of the Yangtze River in China regulate water flow, which directly affects the hydropower production from (and earning potential of) facilities on that river. By maintaining these forests, power output can be maintained in relatively dry years. It has been calculated that maintaining these forests would yield up to 2.2 times as much income as would be gained from harvesting their timber.

Climate change is projected to lead to more frequent low river flows in some areas. Hence, the economic value of forests for flow regulation and hydropower facilities may increase in the future.

Wetlands for flood regulation

Dhaka in Bangladesh suffered a flood in 1998 that submerged 56 percent of the city, affected 1.9 million people, and cost an estimated \$10–\$20 million. The destruction of natural waters and wetlands around the city were partially to blame for these floods. Retention ponds are now required to be maintained to a minimum standard, and a new law prevents the destruction of wetlands.

Flooding in rivers, estuaries, and coastal areas (as well as surface flooding) may become more frequent in certain places because of climate-driven changes in rainfall patterns. Wetlands may thus become increasingly valued for their flood-management benefits.

Sources: Koh 2008; MEA 2005; Monirul Qader Mirza et al. 2005; Bruijnzeel 2004; Guo, Xio, and Li 2000

Box 8. The Nonmarketed Benefits of Natural Pollinators May Be Threatened by Climate Change

A wide range of insect pollinators are found across the globe and are vital for agribusiness. The insect weevils *Elaeidobius subvittatis* and *Elaeidobius kamerunicus* are key oil palm pollinators. Both are native to West Africa, but not to Southeast Asia, where most of the world's oil palms are now grown and where different insect pollinators are more prevalent.

The value of natural pollination in West Africa is typically not considered in investment analyses, despite the financial benefits that it brings. These are illustrated by a study that looked at the effects of the introduction of *E. kamerunicus* to plantations in Malaysia. Within two years, the plantation reported an increase of 29 percent in production of palm oil, and the workforce needed for manual pollination decreased from 2,134 to 1,557. (Clearly, the economic consequences of natural pollination in terms of reduced employment is also an important consideration). Other researchers found that the introduction of *E. kamerunicus* in Malaysia increased oil palm fruit set by 20 percent compared with manual pollination.

Climate change may threaten the economic asset that pollinators represent. Though little is known about their climatic sensitivities, *E. subvittatis* and *E. kamerunicus* have been observed to reduce in numbers under conditions of high rainfall.

Similarly, climate change is thought to be a contributing factor to the recent observed decline in the number of honeybees in the United Kingdom. Honeybees, which are estimated to be worth approximately \$300 million a year to the U.K. economy, are reported to have declined by 10–15 percent in the last two years.

Sources: Harun and Noor 2002; Moura et al. 2008; Corley and Tinker 2003; BBC News 2009; "Datuk Leslie Davidson, a Planter Extraordinaire," posted to the blog Semalu, November 24, 2008, at <http://semalu.blogspot.com/2008/11/datuk-leslie-davidson-planter.html> (accessed October 5, 2009).

SECTOR-SPECIFIC RISKS

As shown above, climate change can have credit and financial, strategic, operational, and legal risk impacts for financial institutions that invest in

climatically vulnerable businesses. The previous section discussed the climatic issues that will create vulnerabilities across investment sectors; this section

explores the risks particular to five key sectors.

Agribusiness

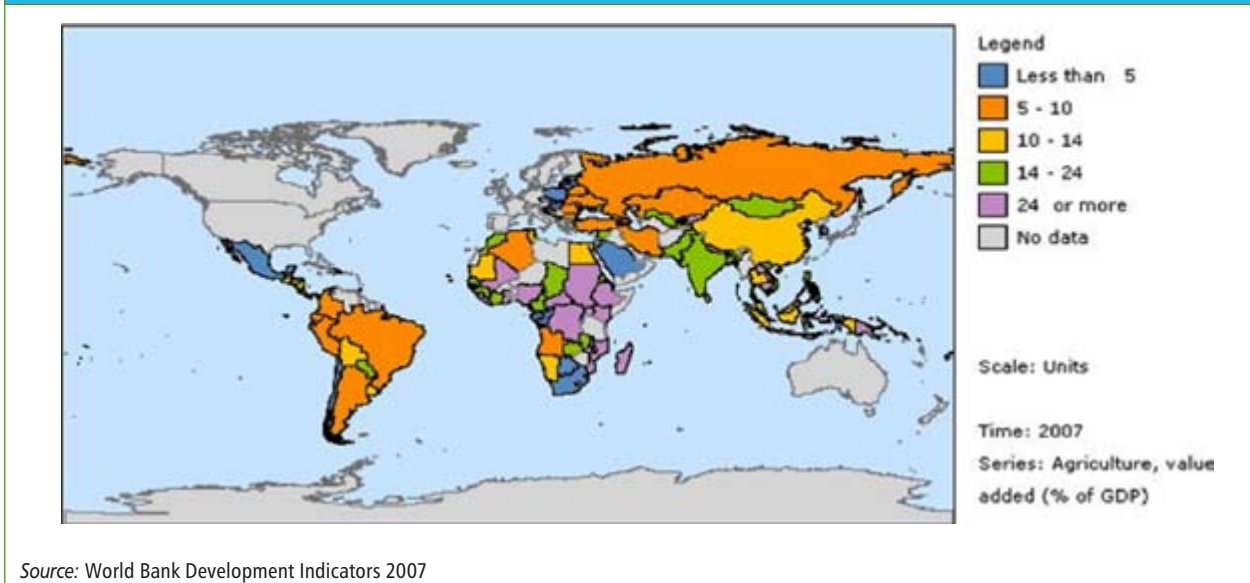
Overview

In many developing countries, agriculture represents a large percentage of national GDP (see **Figure 12**). Any climate-related reductions in crop yield or quality will affect not just investments in those countries, but the economic well-being

of the countries themselves. A report by Weatherbill (2008) found that GDP is also highly sensitive to weather in many wealthy countries, particularly when sensitivity is measured as the total dollar amount that is at risk due to weather in each country. According to this measure, the United States has the

greatest weather sensitivity, more than twice as much as that of the second-ranked country, Japan.

Figure 12. Agricultural Value Added as a Percentage of GDP in Selected Countries



Crop Production and Processing

Because agriculture is highly sensitive to climate, changing climatic conditions will affect crop production in many countries. Changes in temperature, soil moisture, patterns and seasonality of rainfall, and frequency and intensity of extreme weather events will all have consequences for agricultural yields. Rising temperatures and longer growing seasons may increase productivity and provide the opportunity to diversify and grow a greater range of crops in some areas (particularly in northern latitudes over the next 20–50 years), but in other areas a changing climate will constrain growing seasons and reduce crop productivity.

Irrigation and water-storage facilities may become a necessity during some seasons in previously rain-fed regions, while in other regions irrigation systems may come under increasing pressure as agricultural, industrial, and domestic demand and competition for water increase. Coastal agriculture may be affected by sea-level rise and increased salinization. A changing climate could see new pests and diseases affecting crops and livestock. Finally, as consumer demand shifts in response to a changing climate, the agribusiness sector may need to adjust production to remain competitive.

Climate-sensitive crop-processing investments may also suffer from shutdowns or decreased efficiency as a result of higher temperatures and humidity, flood and storm events, water quality and supply difficulties, and incidence of new crop pests and diseases.

Furthermore, decreased supply of some food crops can cause losses in food product output. For example, extended droughts in Australia have already forced the food company Heinz to curtail production of tomato paste there because of a decreased supply of tomatoes. It is reported that the company is considering shifting production out of the country as a result (Chase and Schuchard 2009).

Animal Production and Farming

A changing climate is likely to result in decreased productivity, increased health risks, and increased mortality rates for livestock (see **Box 9**). Extreme high temperatures can lead to animal heat stress, while droughts and dry spells can reduce herd sizes. Changes in temperature and precipitation are likely to result in the introduction of new pests and diseases in previously unaffected areas. A changing climate will also affect the migration and breeding patterns of wild species and will alter their habitat distribution. This could bring wild species into competition with farmed species (e.g., for spawning territory, water, or food). If wild species are protected, it could also mean that animal farming activity comes into conflict with ecological regulations. Finally, changes in climate will impact feed supply, as well as soil and vegetation quality.

Box 9. Extreme Weather Events Can Have Significant Impacts on Livestock Production

In January 2008, southern China was hit by a 1-in-100-year snowstorm. The storm had a disastrous impact on the local pig-breeding industry: piglet death rates reached 30–50 percent (subsequent long-term electricity shortages after the storm caused 100 percent death rates in some places), and farmers suffered extensive physical damage to pens and feeding facilities. Because post-storm sales of feed were sluggish, some feed plants were forced to stop production.

Source: Liu 2008

Forestry and Forest Products

Increases in temperature, changes in seasonal precipitation, and changing levels of atmospheric CO₂ can alter physiological processes in soils and trees, with direct consequences for the future yield and growth of commercial forestry species. The most favorable climatic conditions for forestry species often exist over a relatively small area. As a result, though species may continue to grow in current locations, they may face competition from other species better suited to the new climate conditions. In addition, climate change will cause migration of new pests and diseases that affect individual species.

Increasing temperatures will lead to an increase in forest fires, especially where fires are started as a result of human activity. A study of satellite data revealed that following the 2005 drought in the Amazon Basin, the annual cumulative number of indicators of fire increased 33 percent in relation to the 1999–2005 average (Aragao et al. 2007).

This may result in losses for forestry investments and possible increases in insurance costs or loss of insurance coverage. Depending on the region, however, changes in precipitation frequency and intensity may counteract the risk of more frequent fire activity. Forests in drier areas may also experience yield or quality problems due to an increase in summer droughts. Though forests in water-limited environments are rare, they are often commercially significant within the region. An increase in the number and intensity of storms will increase the risk of damage due to wind throw.

Many pulp and paper facilities depend on large, uninterrupted supplies of water as an input to manufacturing processes, and climate change is expected to lead to reductions in river flows in many regions. If climate change exacerbates water shortages and/or water-quality issues, industrial pulp and paper facilities may be held responsible, increasing their reputational risks. Additionally, the supply chains and transport links on which the pulp and paper sector depends are vulnerable to climate-related disruptions.

Conclusion

These climate change impacts on agribusiness investments mean that—depending on location, type of crop, tree, or livestock, and management practices—agribusiness investments may see their profitability significantly changed in the short to medium term. In some cases, output will be

significantly reduced as a result of incremental changes in temperature and rainfall or of losses due to extreme weather events. OPEX and CAPEX may rise. For example, irrigation may be needed to maintain output. Contingent liabilities may appear as a result of potential losses because of conflicts around access to water and increased fire and disease risk.

Consequently, regional investment performance in the agribusiness sector will be impacted by climate change, as some regions will see the profitability of agribusiness investments reduced.

Water

Overview

The water sector comprises several key business areas that focus on the supply, treatment, and delivery of water and wastewater, the production of electricity from hydropower, and the control of water sources and protection against flooding and sea-level rise. Climate change will affect investments in each of these areas, with impacts that will vary by project purpose and location.

Shifts in precipitation amounts and frequency, temperature increases, changes in snow, ice, and glacier melt, and droughts and extended dry periods can affect water availability, while extreme weather events can damage water infrastructure and lead to pollution of water supplies. Secondary and indirect impacts, such as increased prevalence of diseases and pests and increased soil erosion and runoff, will also have ramifications for water availability and quality.

Climate change is also likely to increase demand for irrigation and drinking water in some areas, which can lead to heightened competition and scarcity of water resources, especially in places currently under water stress.

Between \$678 billion and \$767 billion will be required in developing countries by 2030 to meet additional water demands due to climate change, economic growth, and population increases. Climate change alone is estimated to precipitate the need for 25 percent of this investment requirement, amounting to between \$170 billion and \$192 billion, demonstrating the scale of the impacts climate change will have on this sector—and therefore for investments within it (UNFCCC 2007).

Water Supply

Businesses and government authorities involved in the water and sanitation sector will face substantial climate-related impacts that will affect the availability and quality of domestic, industrial/commercial, and agricultural water.

Droughts and extended dry periods may constrain water companies' ability to provide water supplies for large urban and rural populations and for industries that rely heavily upon water. Extreme weather events such as floods and strong storms can damage water-purification facilities and main water lines, leading to disruptions in water supply. Further, sea-level rise may lead to increased salinization of groundwater supplies for coastal populations.

Climate change will likely lead to changes in runoff characteristics, with the potential for increased breakdown of soils in upland areas, discoloration, changes in nutrient levels, and reduced dilution of pollutants, all of which can contribute to the deterioration of raw water quality. Higher temperatures may also create more favorable conditions for bacteriological failures of treated water. As a consequence, water companies and authorities may need to augment treatment processes, which will entail an increase in costs. Sedimentation of reservoirs may also contribute to a tightening of water supplies.

In addition, climate change is likely to have an impact on water demand. Increased competition for increasingly limited water supplies will compound water-supply problems. These impacts will be more severe in areas of current water stress and in the world's least developed countries (see **Box 10**).

Loss of or disruption to water supplies can have numerous and severe consequences for businesses, communities, and entire economies. Climate change will exacerbate the challenges that companies and government authorities already face in meeting rising water demand.

Box 10. Change Impacts on Water Supply Are Likely to Be More Severe in Areas of Current Water Stress

Water availability in many areas of India has remained constant or even decreased in response to droughts, lower annual rainfall amounts, and decreasing groundwater supplies. This has placed enormous pressure on communities and businesses. In Bhopal, a city of 1.8 million in northwest India, residents have been limited to 30 minutes of water every other day since October 2008. When the monsoon season underperformed in early 2009, rationing was increased to once every three days. Even in Mumbai, which experienced record rain and flooding in early and mid-2009, water supplies were cut by 30 percent in July 2009. In some instances, these water shortages have led to violence, with conflicts regularly breaking out over water supplies delivered via tankers in the north of the country.

Source: Chamberlain 2009

Wastewater Treatment and Services

Climate impacts may damage assets, affect operations, and interrupt services in the wastewater-treatment sector, increasing costs for private companies and government authorities providing sanitation services.

Extreme weather events, such as storms and landslides, can damage sewage-treatment facilities and sewer lines. Floods can overwhelm sewers and wastewater-treatment plants, heightening the risk of tainted water supplies and land contamination, as well as increasing public health risks. In low- and middle-income countries, inadequate water

and sanitation services are often overwhelmed by flooding, leading to spikes in diarrheal diseases and polluted groundwater following heavy precipitation events (see **Box 11**). In fact, almost 450,000 children under the age of five die every year in Uganda from diarrheal diseases spread by inadequate sanitation infrastructure (Taylor et al. 2008).

Box 11. Impacts on Water-Treatment Assets

In July 2009, heavy rains in Inner Mongolia in China caused a power outage at a sewage pumping station, contaminating local water supplies. As a result, more than 4,300 people in the town of Chifeng fell ill with diarrhea, fever, and vomiting after drinking tap water. These situations are common in areas where sewage infrastructure cannot meet growing demand and is poorly maintained.

Source: Wai-yin Kwok 2009

Climate change may also necessitate additional wastewater-treatment processes because of deterioration in water quality and lower flows in watercourses, which reduce the watercourses' capacity to dilute pollutants before the water reaches treatment facilities. Furthermore, treatment processes may need to be strengthened in order to meet existing and/or future effluent-discharge standards required to protect downstream water environments in response to climate change. Higher temperatures can cause higher levels of odor and flies, leading to reputational and/or legal risks to sanitation providers.

Water Infrastructure

Infrastructure for both water supply and wastewater treatment is at risk from climate change because water industry assets traditionally have comparatively long asset lives, and they may perform less well under future climatic conditions. Designing and building assets that are capable of delivering and maintaining services (while taking account of changing customer demands and regulatory consents driven by climate change) will be a major challenge if premature asset write-off is to be avoided.

Flood management and drainage systems are likely to be compromised by sea-level rise, storm surges, coastal erosion, and changes in patterns of precipitation, resulting in asset damage, service disruption, consent and regulatory failures, and disruptions to off-set utilities. Rising temperatures will also affect the efficiency and operations of physical plant and equipment such as compressors, pumps, and generators.

Climate impacts on electricity production and transmission can cause disruptions to power supplies, which increase the risk of failure in the supply of water and the treatment of wastewater, as well as pumping in network systems. Desalination plants rely on steady energy sources to purify seawater for large populations in arid environments. If power supply to these facilities were cut or damaged by an extreme weather event, the repercussions for drinking-water supplies for large urban areas could be substantial.

Increased temperatures and reduced rainfall during some seasons may increase the septicity of sewer systems due to reduced flows as well as higher rates of bacterial decay, which will lead to odor problems emanating from sewage-transport and -treatment infrastructure. Higher temperatures will also translate to higher susceptibility of wastewater-treatment facilities to fly and vermin infestations, leading to increased risk of public complaints and/or legal action.

Demands for increased efficiency of water-transport infrastructure and decreased leakage will raise CAPEX. These direct and indirect climate impacts will translate to direct costs for businesses, governments, and the public and will affect investments in the water industry.

Conclusion

Overall, between \$8 billion and \$9 billion is required to help the water and sanitation sector in non-Annex I countries adapt to climate impacts (UNFCCC 2007). This figure is significant in part because the water industry's long-lived assets, sprawling transportation networks, and vulnerable infrastructure are all at risk of damages as a result of climate impacts.

Implications for investments in the utilities sector, which includes water and wastewater treatment, could be severe. Investments in regions currently experiencing water stress, such as South Asia, where infrastructure is often vulnerable and climate change is likely to increase demand for water, are also at high risk. Incorporating these risks into investment decision making will help insulate investors against the most damaging losses.

Electric Power

Overview

Like the water sector, electricity production is heavily dependent upon long-lived and capital-intensive assets that are highly vulnerable to climate change.

Direct climate risks to the electricity sector include increasingly frequent and intense extreme weather events, such as floods, droughts and extended dry periods, ice storms, high winds, and heat waves. Indirect climatic changes, including shifts in demand patterns and peaks, will also significantly impact businesses in this sector. For example, in a changing climate, wholesale and retail electricity prices may be more volatile.

Electricity markets will also shift, with increased demand for cooling during hotter summers straining production facilities and transmission and distribution networks during a time of year that is traditionally reserved for maintenance. Cooler winters will decrease demand and potentially dent revenues. Meeting higher peak demand loads may require significant CAPEX in old and new electricity assets, especially if the electric-car market grows.

These impacts could have substantial consequences for electricity producers, transmitters, distributors, and suppliers, as their CAPEX and OPEX may rise, their maintenance budgets may need to increase, and their assets may be written off earlier than expected. Further, climate-related plant shutdowns or failures in distribution or supply can damage a company's bottom line and harm its reputation.

Hydropower

Within the electricity sector, hydropower production will likely be most affected.

Increased variability of precipitation will have substantial impacts on hydropower production, as will changes in the timing and extent of glacier and snow-cover melting. For facilities located downstream of glaciers, increased ice melting will aggravate the risk of glacier lake outburst flooding.

Droughts and extended dry periods can reduce river flows, deplete reservoirs, and significantly decrease hydropower output, dramatically reducing national energy supplies and leading to shortages and blackout periods. Climate-related competition for water resources (as discussed in the previous section), especially in areas of current water stress, will further constrain hydropower water supplies.

These impacts will be even more severe when coupled with overall increased electricity demands and higher peak requirements in summers.

More intense and frequent heavy rainfall may put greater stress on dams that were designed without taking into account future climate change and may increase their risk of overflow. Facilities may be at higher risk of being flooded. Increased water sedimentation because of greater runoff may affect turbine performance.

In areas that heavily depend on hydropower production such as Brazil, changes in river flow could cripple national GDP. Investments in these countries and in this sector are therefore also vulnerable.

Other renewable energy production technologies are also highly vulnerable to weather conditions. Solar- and wind-power generation are completely dependent on weather, and biofuels production is influenced by climatic conditions affecting growth, as well as climate-driven changes in the incidence of pests and diseases.

Non-hydropower Electricity Production

Non-hydropower electricity-generation companies are also vulnerable to climate change because of their reliance upon long-lived and capital-intensive assets.

They can rely extensively on freshwater for cooling (see **Box 12**). Droughts and extended dry periods could jeopardize water availability. Hotter summers could raise freshwater temperatures, increasing water cooling requirements. This may increase the costs of compliance with regulations that require receiving water bodies not to exceed a certain temperature threshold set to protect living fauna and flora. These impacts on water used for cooling could cause costly operating constraints or shutdowns.

In addition, higher ambient air temperatures can decrease turbine efficiency and affect the efficiency of compressors, pumps, generators, and other equipment in electricity-production facilities.

Indirect impacts can also damage companies' bottom lines. Distribution of raw materials can be affected by extreme weather events. As electricity production from fossil fuels relies particularly heavily on ports and other marine facilities (which are vulnerable to numerous climatic impacts, including sea-level rise, coastal erosion, flooding, and storm surges), supply chains may be at risk from climate impacts.

Box 12. Water Requirements Differ across Energy-Production Assets

The water requirements of different energy production assets differ greatly (see table below).

Among production based on renewable energy sources, hydropower is the largest water consumer. Solar and wind power have very small water requirements (stemming from the production and extraction of raw materials for companies' assets). First-generation biofuel production has a large water footprint, when growing irrigated crops and refining fuel are taken into account.

Thermoelectric power generation (based on oil, coal, gas, or nuclear power) can also have large water requirements, especially for cooling.

Water Requirements for Different Energy-Generation Technologies

Energy type	Total water consumed per megawatt hour (m ³ /MWh)	Water consumption required for U.S. daily energy production (millions of m ³) ²²
Solar	0.0001	0.011
Wind	0.0001	0.011
Gas	1	11
Coal	2	22
Nuclear	2.5	27.5
Oil	4	44
Hydropower	68	748
Biofuel (1st generation)	178	1958

Note: Totals are averaged by plant type.

Source: Morrison et al. 2009

Climate change risks to water availability and water discharge may greatly influence project operational risks, depending on the assets considered.

Sources: Morrison et al. 2009; DHI 2008]

Other Electricity Assets

Electricity assets—including transmission, distribution, and supply systems—are also vulnerable to extreme weather events, particularly when those events exceed asset design thresholds or industry operational standards.

Drought-induced forest fires, mudslides, floods, storm events, high winds, and ice storms can damage poles, unearth

buried power lines, and cut off supply to customers. This can have negative consequences for brand value and can result in revenue reductions

Conclusion

The electricity sector is particularly vulnerable to a variety of climate impacts, including decreased availability of water for power production and for cooling and increased risks of storm and flood events.

Investments in countries or locations that are particularly exposed to climate change (on the coast, e.g., or in areas already experiencing water stress) or that have limited capacity for adaptation are the most vulnerable. Incorporating these climate risks into investment decision making will be critical for insulating them against the worst impacts and potential financial losses.

Transport

Overview

Transportation infrastructure and assets are extremely vulnerable to the impacts of climate change. Climatic changes that can affect these networks and assets include sea-level rise, coastal erosion, higher temperatures, melting permafrost, changing patterns and variability of precipitation, and increasingly frequent and intense extreme weather events.

These changes can all disrupt transportation infrastructure and networks, resulting in losses for businesses relying upon them and increased costs to the governments and companies charged with maintaining them. South African mining company Exxaro Resources Ltd., in its response to the 2008 CDP questionnaire, estimated these costs, finding that two

months of lost export opportunities resulting from transportation and/or infrastructure damage would cause revenue losses of \$60 million.

As climate change impacts become more frequent and severe, businesses both within and relying upon the transportation sector should expect and plan for disruptions to climatically vulnerable transportation systems and assets and for the subsequent economic and financial impacts, and investors in these businesses should be particularly aware of the potential impacts on their bottom line.

Land Transport

Precipitation and extreme weather events can damage roads, rails, and other land-based transportation and linkage infrastructure. For example, floods and storm surges can wash out bridges, sections of rail, and highways. Increased temperatures and hotter summers can buckle rails and crack roads, increasing OPEX for governments and creating transport inefficiencies and supply-chain disruption for businesses. Sea-level rise, coastal erosion, and tidal flooding can threaten networks that are located near the coast. The city of Cartagena, Colombia, for example, has experienced serious tidal flooding in the neighborhoods and urban areas around its port. With some events lasting 15 days or more, local and commercial transport can be seriously disrupted (CIOH 2008).

Heavy precipitation and subsequent flood events can have major impacts on urban transport systems. For example, flooding in Boston's surface transport network is expected to generate significant costs due to lost workdays, sales, and production (Suarez et al. 2005); these costs are small, however, when compared to the projected costs of flooding damages to the infrastructure itself (Kirshen, Ruth, and Anderson 2006). Road-related accidents due to extreme events can also be costly, amounting to \$1 billion annually in Canada alone (IPCC WGII 2007).

Costs due to flooding can be especially large for urban underground rail systems. In the past decade, there have been four cases where such systems have suffered from flooding damages worth more than \$13 million. Underground systems are also vulnerable to speed restrictions, delays, and health risks during prolonged periods of hot weather. There have also been numerous instances of lesser damages in the past (Tamiotti et al. 2009); however, even these damages can be expected to increase and become more frequent as extreme events become more intense and common.

Maritime Transport

Marine transport accounts for around 90 percent of world trade by volume and 70 percent by value (Tamiotti 2009). As a result, climate-related disruptions to maritime transport infrastructure and assets can have significant ramifications for the global economy, not to mention individual businesses.

Ports and coastal areas are particularly vulnerable to numerous climate impacts. Heavy precipitation events (in conjunction with land-use changes) can contribute to sedimentation of ports, channels, and other marine transportation routes, causing direct damage to infrastructure as well as disrupting transportation itself.

The total value of assets in port cities exposed to coastal flooding due to storm surge in 2005 was estimated to be \$3 trillion (around 5 percent of global GDP in 2005). The majority of these assets are found in the developed world (Nicholls et al. 2007).^b By the 2070s, this figure is projected to top \$35 trillion (roughly 9 percent

of projected annual GDP in this period), and most of the top 10 cities at risk will likely be found in developing countries.^c

Indirect impacts such as energy shortages and disruptions to supply chains at ports can also cause significant losses. For instance, Guangzhou, one of the most important cities in China's Pearl River Delta, experienced 716 acute power shortages in the first three months of 2005 alone, costing the city approximately \$1.3 billion in lost industrial output (Tracy, Trumbull, and Loh 2006).

Climate change will not only pose risks to businesses relying upon marine transport infrastructure and operating within the transportation sector; it could also lead to opportunities (see Error! Reference source not found.).

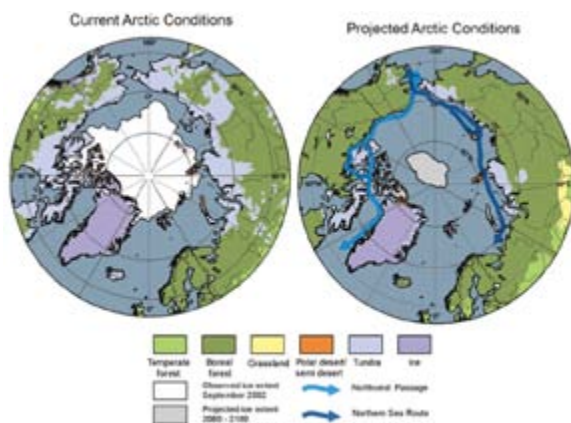
^b The study focused on 136 port cities with populations of 1 million people or more that are exposed to 1-in-100-year flood events. The 10 cities with the highest asset value at risk in 2005 were Miami, Greater New York, New Orleans, Osaka-Kobe, Tokyo, Amsterdam, Rotterdam, Nagoya, Tampa-St. Petersburg, and Virginia Beach.

^c The 10 cities with highest asset value at risk in the 2070s are projected to be Miami, Guangzhou, Greater New York, Kolkata, Shanghai, Mumbai, Tianjin, Tokyo, Hong Kong, and Bangkok.

Box 13. New Maritime Transport Routes May Open Up

As temperatures increase, the amount of ice-free access to ports will increase. In Polar Regions, new routes may become available as ice melts and formerly closed shipping lanes open up. This is especially important for oil, gas, and mining companies, as they regularly operate in the Arctic Sea.

Projected Arctic Ice Melt by the 2080s



Source: IPCC WG2 2007

Oil, Gas, and Mining

Overview

The oil, gas, and mining sectors are exposed to climate impacts because of their reliance upon long-lived and capital-intensive assets, their global reach, their extensive product-transportation networks, and their deep and widespread supply chains, vulnerable to disruption.

Most companies in these sectors operate in the regions that are the most vulnerable to climate change, including the Arctic and developing countries. Further, oil, gas, and mining businesses rely on workforces and communities that are geographically and socioeconomically vulnerable to a changing climate.

As a result, these sectors are particularly at risk of economic losses, damages to reputation and brand value, and legal and regulatory challenges.

Oil and Gas

Floods and increasingly frequent and intense extreme weather events (including hurricanes and tropical storms) can significantly damage the assets and infrastructure upon which oil and gas companies rely for discovery, extraction, refining, and transportation of product to market. As most of these assets have long lifetimes and are very capital-intensive, climate resilience should be incorporated in their design and construction to minimize and perhaps even avoid costs as climate change impacts worsen.

Oil and gas companies are often at risk because of the areas in which they operate. Melting permafrost can damage assets in polar regions, especially those used for exploration and drilling. Oil and gas pipelines and other transportation infrastructure used to deliver products from these regions to market are also vulnerable to permafrost thaw (see **Box 14**).

As sea levels rise, wave heights increase, and tropical storms become more intense, air gaps between the sea and the bottom of oil and gas platforms must be increased, at significant costs. Making these platforms resilient to more severe storms will be more expensive if undertaken as a retrofitting exercise, rather than implemented during the design stage.

Increased temperatures can decrease the efficiency of equipment essential to oil and gas operations, including pumps, compressors, and generators. Warmer winters can also lead to reduced demand for heat, decreasing revenue for gas companies that rely strongly on winter sales (Mohl and Howe 2007). Oil and gas decommissioning costs may also be higher, depending on how future climatic conditions will affect sites (see **Box 15**).

Indirect impacts can affect oil and gas companies just as significantly as direct impacts. For example, insurance costs for rigs and platforms in the Gulf of Mexico are rising as a result of increased damage from hurricanes and windstorms. As a result, more oil and gas asset owners are self-insuring and absorbing the risks of damages themselves.

Oil and gas companies are also increasingly at risk from litigation. If climate risks are not managed and the local community is negatively affected (e.g., when thawing ground creates new pollutant pathways, leading to contamination of local environments by industrial operations), investments may be at risk. A shift is emerging in public and regulatory expectations from mere compliance with the letter of the law to compliance with the spirit of the law. Not only have the number of class-action lawsuits against Fortune 500 companies remained very high in the past 10 years, but the average settlement value has consistently increased, reaching \$32 million in securities class-action lawsuits in 2004 alone (Lye and Muller 2004). This is all occurring against a backdrop of an increasingly litigious American society, where total tort costs increased from less than \$25 million in 1976 to over \$200 million in 2001.

Box 14. Melting of Ice and Permafrost Shortens Transport Season

Melting permafrost will disrupt access to Arctic regions and damage transportation infrastructure and assets. Higher temperatures also mean that ice road and bridge seasons (essential for Arctic communities and investments) are significantly shortened.

The number of days per year during which travel is allowed on the Alaskan tundra has decreased from over 200 to approximately 100 over the past 30 years, resulting in a 50 percent reduction in the number of days that oil and gas exploration and extraction equipment can be used. Furthermore, opening and closing dates for tundra travel in northern Alaska have shifted closer together due to longer summers and warmer winters.

Source: ACIA 2004

Box 15. Decommissioning Provisions May Underestimate Future Costs in a Changing Climate

Decommissioning costs represent a significant part of the financial risk of oil, gas, and mining investments, because the majority of cash flows occur at the end of the project's life.

For example, as set out in an assessment of leading oil and gas companies by Standard and Poor's (S&P), decommissioning provisions (which are treated as additions to debt) equate to about 45 percent of the overall future debt burden.

The accounting rule for decommissioning provisions under the International Accounting Standards (IAS 37) requires a company to recognize a liability as soon as the decommissioning obligation is created, which normally occurs at the time the facility is constructed and the damage that needs to be restored is done. S&P found that the scale of the decommissioning provisions tends to be based on management's judgment rather than third-party appraisals.

Because of climate change, new and emerging risks must be taken into account when considering the decommissioning costs for contaminated assets: increased sea levels and coastal erosion, permafrost thaw, increased river flooding, and changes in sea conditions (temperature and acidity). All of these have the potential to create challenges for the decommissioning of assets:

- Saline intrusion and rising groundwater levels may create new source-pathway-receptor relationships, increasing risks associated with contaminated land.
- Increases in flood levels will result in greater risks to decommissioned sites, requiring higher levels of flood protection (particularly relevant for nuclear power stations).
- When regulations or contracts require the rehabilitation of mining sites back to their original ecological state, climate change impacts on ground conditions, species, and biological processes may have costly implications that are not yet well understood.

Risk-management mechanisms, such as insurance bonds, based on risk assessments that did not take climate change into account may prove to be inadequate to protect investments from further liabilities and litigation risks.

When appraising future investments with decommissioning liabilities, each asset type, the area in which it is located, and the intended after-use of the site may have to be examined with future climatic changes in mind in order to appropriately estimate cash flow needs toward the end of the project.

Source: S&P 2007

Mining

Climate impacts such as flooding, melting permafrost, and intense rainfall can lead to waste and wastewater spills from mines and associated activities. This is a particular concern for mines operating dams and tailings for waste containment, which may be vulnerable to climate-induced damages that would open mining companies to legal and regulatory liabilities and potentially massive cleanup costs (see **Box 16**).

Box 16. Companies Can Be Held Responsible for Climate Impacts on Local Communities and Environments

Australia's Environmental Protection Agency opened an investigation into several companies after pollution overflowed from their mines into surrounding areas following heavy rains. Newmont Mining faced pressure from the Indonesian government over whether it had polluted a bay with arsenic and mercury from a nearby gold mine. In Romania, heavy rains and a quick thaw caused by unusually high temperatures were partially responsible for the breaking of a tailings dam at Baia Mare that spilled cyanide-contaminated wastewater from gold production into local rivers and eventually the Danube.

Sources: Timms 2009; Perlez 2006; REC 2000

Flood events can also shut down mines if excess amounts of water render them inoperable. For example, heavy rainfall in Australia in early 2007 was blamed for lower gold-production rates, which represented an 8 percent decrease compared to the same quarter in 2006 (Sydney Morning Herald 2007). Exxaro Resources Ltd. has estimated the impacts of flooding, finding that it would lose \$30 million if a 50 percent loss of production in one of its open-cast mining operations occurred over two weeks due to floods.

Droughts, too, can have significant impacts on mining, as many mining processes require substantial amounts of water. Further, many mining companies operate in disease-prone areas that are already vulnerable to the impacts of increasing temperatures, including greater water stresses and even higher disease occurrence rates. Workforces could be affected by these climate-related disease impacts, reducing mines' productivity. In polar regions, melting ice can disrupt transportation systems upon which mining operations rely for supplies and equipment, as well as distribution of resources and mining products.

But climate change will not only bring risks for mining companies—it may also bring some opportunities. For example, changing sea ice conditions in the high latitudes and the Arctic (see **Box 13** above) could potentially open up new areas of mining exploration and production. Also, some mining facilities rely upon currently short summers for operation and could benefit from longer periods of higher temperatures and increased transportation routes.

Conclusion

Investments in the oil, gas, and mining sectors are vulnerable to numerous climate impacts, ranging from more intense and frequent extreme weather events to gradual permafrost melt. All of these impacts pose a risk to companies' bottom line and could result in significant losses for businesses if they are not incorporated into risk-management plans, asset design and construction, and management-level decision making.

APPENDIX. GREENHOUSE GAS EMISSIONS SCENARIOS

To provide a basis for estimating future climate change, the IPCC prepared the Special Report on Emissions Scenarios (SRES; Naki enovi and Swart 2000), detailing 40 GHG and sulphate aerosol emission scenarios that combine a variety of assumptions about demographic, economic, and technological factors likely to influence future emissions.

Each scenario represents a plausible future pathway of emissions of GHG and other pollutants that can affect the climate. There are several scenario variations within each of four “story lines”: A1, A2, B1, and B2. Projected carbon dioxide, methane, nitrous oxide, and sulphate aerosol emissions based on these scenarios are shown in **Figure 16** below for six “marker scenarios.”

A1: The A1 story line describes a future world of very rapid economic growth, a global population that peaks in midcentury and declines thereafter, and the rapid introduction of new and more efficient technologies. Major underlying themes are convergence among regions, capacity building, and increased cultural and social interaction, with a substantial reduction in regional differences in per capita income. The A1 story line

develops into three scenario groups that describe alternative directions of technological change in the energy system. They are distinguished by their technological emphasis: fossil intensive (A1FI), nonfossil energy sources and technologies (A1T), or a balance across all sources (A1B—where “balanced” is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy-supply and end-use technologies).

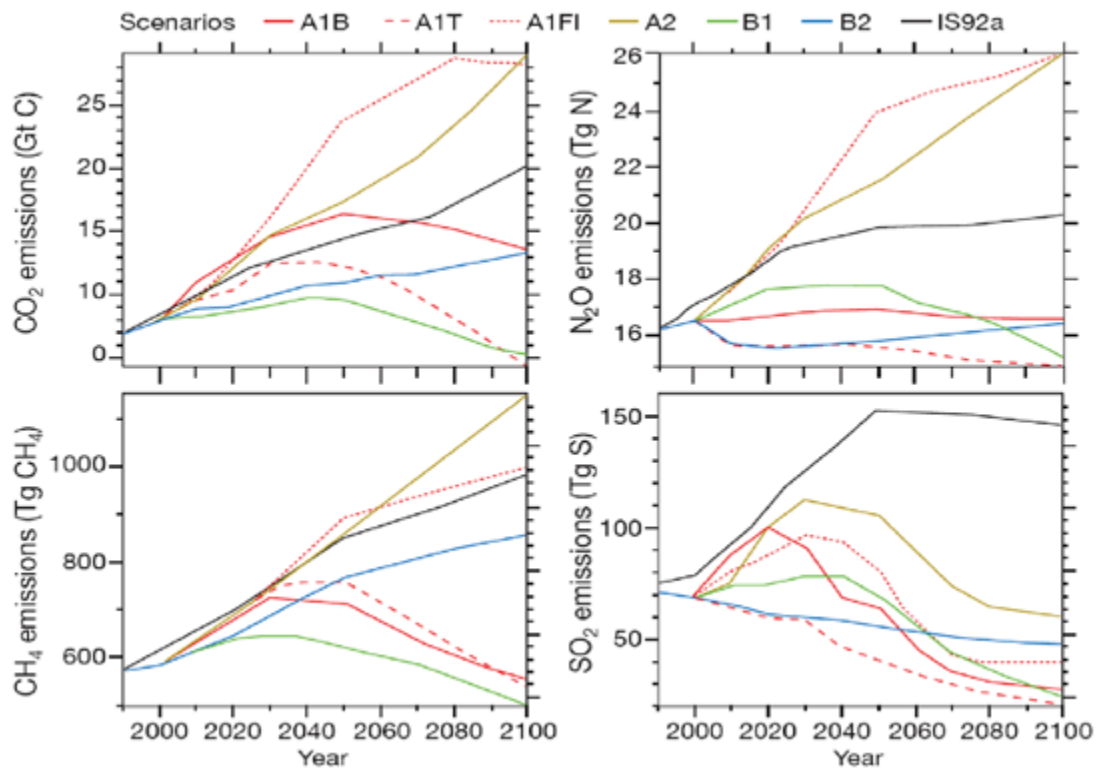
A2: The A2 story line describes a very heterogeneous world. The underlying theme is self-reliance and preservation of local identities. Fertility patterns across regions converge very slowly, which results in continuously increasing population. Economic development is primarily regionally oriented, and per capita economic growth and technological change are more fragmented and slower than in other story lines.

B1: The B1 story line describes a convergent world with the same global population as in the A1 story line (one that peaks in midcentury and declines thereafter), but with rapid change in economic structures toward a service and information economy, with

reductions in material intensity and the introduction of clean and resource-efficient technologies. The emphasis is on global solutions to economic, social, and environmental sustainability, including improved equity, but without additional climate initiatives—that is, not including implementation of the United Nations Framework Convention on Climate Change or the Kyoto Protocol.

B2: The B2 story line describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with a continuously increasing global population, at a rate lower than that in A2, intermediate levels of economic development, and less rapid and more diverse technological change than in B1 and A1. While the scenario is also oriented toward environmental protection and social equity, it focuses on the local and regional levels.

Figure 13. Anthropogenic Emissions of CO₂, CH₄, N₂O, and SO₂ for Six SRES Scenarios and the IS92a Scenario, for Comparison



Note: CO₂ = carbon dioxide; CH₄ = methane; N₂O = nitrous oxide; SO₂ = sulphur dioxide. The IS92a scenario is drawn from the from the 1996 IPCC Second Assessment Report.

Source: Nakicenovic and Swart 2000

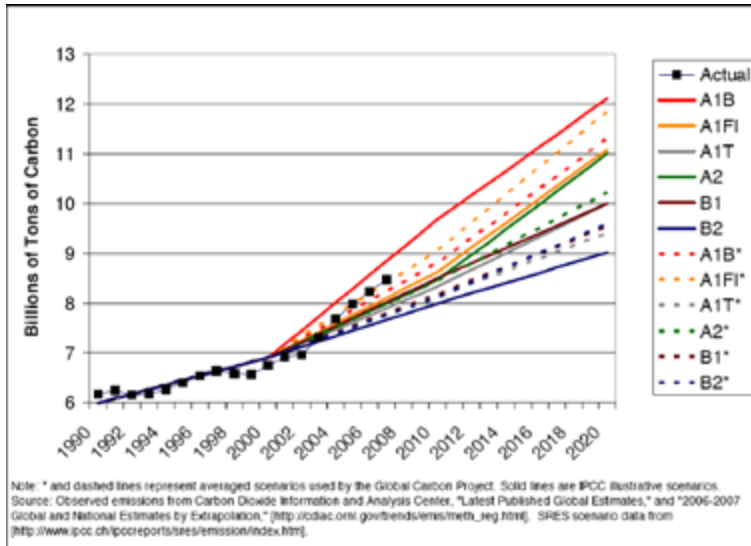
The IPCC GHG emission scenarios represent different possible GHG emission trajectories, smoothed over several decades, based on different possible interpretations of the future. All are considered equally sound by the IPCC, and no probabilities are attached. However, some scientists have warned that GHG emissions are rising more rapidly than expected.

Figure 14 shows that the trend of current emissions is at the top of the range projected by IPCC emission scenarios.

Depending on which GHG emission scenario is followed, the earth will experience different degrees of future climate change from the midcentury onward (IPCC WGI 2007). Climatic

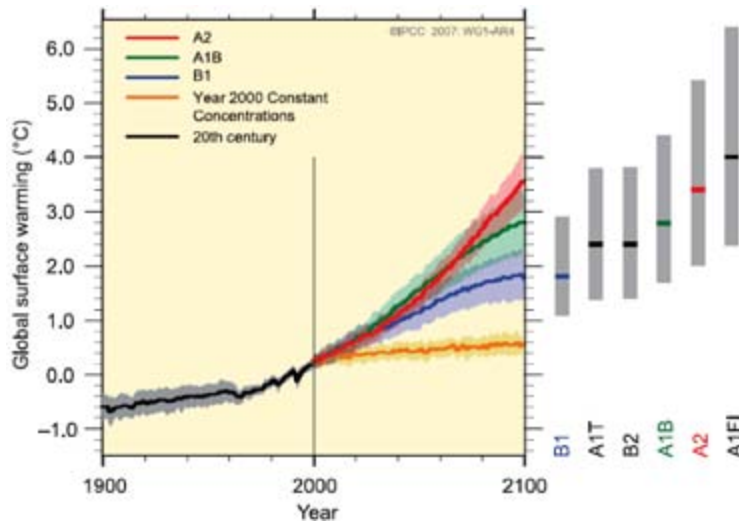
changes from the present day to about the 2040s are already built into the climate system (see **Figure 15**).

Figure 14. Comparison of Recent Actual GHG Emissions with the IPCC GHG Emission Scenarios



Source: Legett and Logan 2008

Figure 15. Average Global Temperature Increase (°C) for Different GHG Emission Scenarios, Based on an Average across Different Global Climate Models



Source: IPCC WGI 2007

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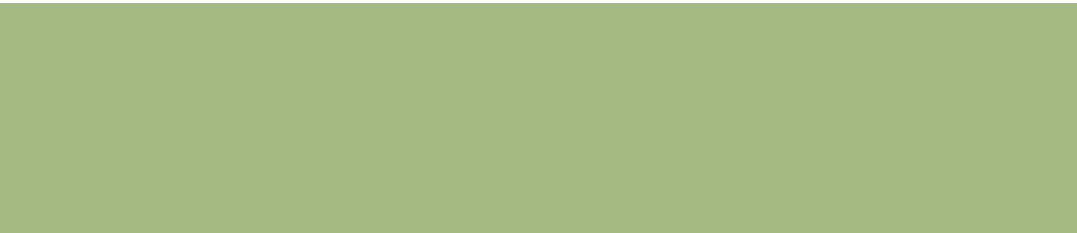
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