The Implications of Climate Change and Environmental Challenges for RBS

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Executive Summary

Climate change will create tremendous risks and opportunities for many industries, including finance and banking. Probing questions are already being asked about the long-term viability of fossil-fuel-intensive business models, and a great deal of money has already been made and lost betting on the direction and pace of the low-carbon transition. The implications for financial markets and banks are also likely to be significant. Various banks are carbon neutral, and some are adopting internal carbon prices. Regulators are really only just beginning to focus on the climate change impacts for the banking sector, and new disclosure requirements and even capital adequacy requirements may emerge in the near future.

This report explores the possible implications of climate change for the financial sector, for banks in general and, to the extent possible for an external academic institution, specific impacts on RBS. There are three main conceptual elements. First, we provide a structure for thinking about the impacts of climate change on banks, set out in Tables 1 and 2 below. Second, we identify a long list of risks and opportunities, spelled out in more detail in the body of the report. Third, we subjectively assess and prioritise risks and opportunities for RBS, based on our expertise in climate change impacts, policy and awareness of the functioning of the financial system. These are set out in Figure 1 and the associated discussion below.

Our structure for assessing the impact of climate change on banks is broken down into three dimensions: impacts can create (1) risks or opportunities which can be (2) direct or indirect (via clients); and which can arise from (3) the policy, regulatory and market response to the threat of future climate change ("mitigation"), as shown in Table 1, or emerge from the physical impacts from climate change or our attempts to adapt to them ("impacts and adaptation"), as shown in Table 2. For instance, one area of focus for this report is the bottom left cell in Table 1: the indirect impact of climate policy on RBS through shifts in the creditworthiness or even bankruptcy risk of clients in key lending sectors.

Table 1. Climate policy impacts on banks ("Mitigation")

	Risks	Opportunities
Direct	Tougher regulatory requirements on: – disclosure – risk-weighting of assets Tougher diligence requirements for financing high-carbon projects	Reduce own emissions to save money and improve brand Create new businesses in green financial products (e.g. emissions trading)
Indirect (via clients)	Reduced creditworthiness of GHG-intensive clients due to tougher regulation and shifting preferences Potential bankruptcy of clients within GHG-intensive supply chains	Improved creditworthiness of clients in cleaner technologies, processes and climate-related products and services Acquire new clients that emerge with policy-driven low-carbon markets

Table 2. Physical climate impacts on banks ("Impacts and Adaptation")

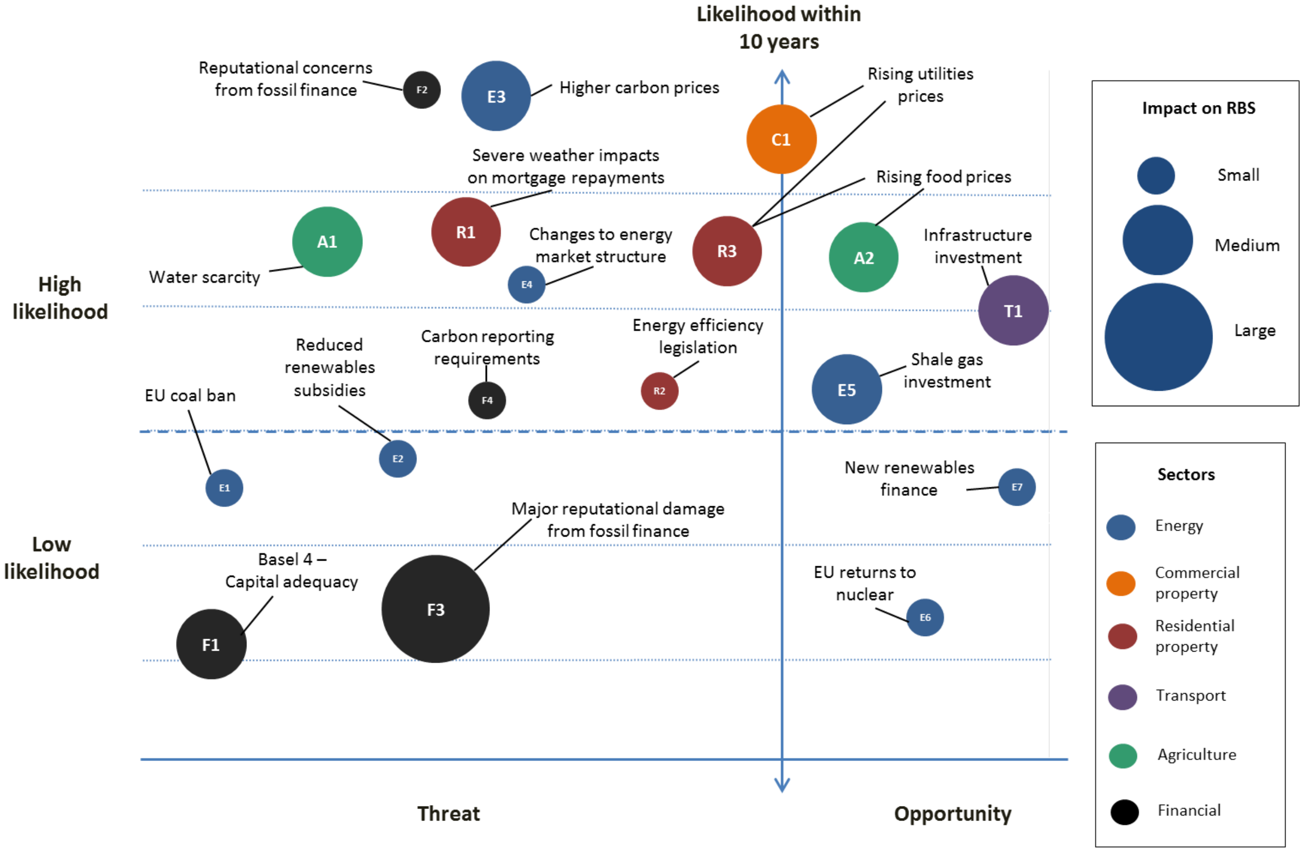
	Risks	Opportunities
Direct	Damage to bank assets (e.g. branches)	Rise in asset values in climate-secure locations
Indirect (via clients)	Reduced creditworthiness of clients vulnerable to climate impacts on assets and supply chains	Acquire new clients offering products/services for adapting to climate changes

While there can be no guarantee that the long list of risks presented in the body of the report is exhaustive, it has been developed by examining hundreds of relevant academic papers and by leveraging in-house expertise at Oxford. At RBS's request, we have focused lending, rather than managed or proprietary investments, within the property (14.5% of lending), energy (2.8%), agriculture (3.0%) and transport (5.5%) sectors, given that these are the largest RBS lending sectors relevant to climate-related risks. From a geographical perspective, we have focused on the United Kingdom in particular, but also the USA and to a lesser extent Europe and Asia.

Distilling risks and opportunities in these sectors and geographies down into the top 15-20 was not straightforward. To communicate the features of these impacts as efficiently as possible, we have located the relevant risks and opportunities on Figure 1 below. This provides an overall visual picture of how climate change could affect RBS, through policy responses and physical climate impacts. The first broad observation is that there is already a reasonable number of risks and opportunities which we would consider to have moderate to high likelihood over a 10 year timeframe. In other words, this is not primarily a list of more speculative low-probability, high-gravity impacts. That said, low-probability high-gravity risks also exist, such as the risk of major reputational damage from RBS's lending to fossil fuel developments. Second, no single sector dominates. Other than in energy, there is a reasonable spread of risks and opportunities across sectors. Third, while there are plenty of risks, there are opportunities for RBS too. Climate change threatens to shake up the established order, creating risks for incumbents but also opportunities for forward-looking firms.

The energy sector appears to be a vector for a disproportionate share of climate risks and opportunities, despite being a small proportion of the overall lending portfolio. The energy sector also creates the greatest reputation risk, as recently observed with the publication of a provocative report on "RBS's true carbon emissions 2012" (World Development Movement, 2013). While this report may or may not be accurate, the point remains that reputations can and likely will be harmed from fossil-heavy exposure as the physical damages from climate change begin to mount.

Figure 1. Top Climate Risks and Opportunities for RBS



While ranking uncertain risks is necessarily a subjective exercise, we consider that the top five risks for RBS within the next 10 years in order of materiality are the following:

- **F2/F3: Reputational damage from fossil finance.** We believe that fossil finance simultaneously involves a *high* likelihood of *small* reputational impact for RBS, as well as a *low* likelihood of very *large* reputational damage. For instance, whereas a degree of moderate negative publicity from fossil finance is practically guaranteed over the next decade, a disaster like Deepwater Horizon may produce a disproportionate reputational impact on operators and finance providers. For at least the next 10-15 years, continued global investment in fossil fuels is inevitable, however, and will contribute to raising living standards and prosperity. So the risk of major reputational damage is low. However, the risks from fossil investments will rise as time passes.

- **R3/C1/A2: Rising utility and food prices.** As more (high-capex, low-opex) renewables come onto EU grids, residual wholesale prices will fall and become more volatile, and consumers pay levies to cover the renewable costs. This has already noticeably affected the credit of large established utilities in Germany, previously thought invincible, and could strain homeowners' ability to meet mortgage payments. Within the agricultural sector, food price increases transfer value from consumers to producers. This is likely to improve credit of some of RBS's clients in the sector but hurt residential incomes and hence mortgage affordability.

- **E3: Higher carbon prices.** While the UK carbon price floor freeze is likely to remain in place, globally carbon prices are expected to rise between now and 2024. This will reduce the returns from high-carbon investments, potentially even stranding some assets on a longer timescale. It is notable that many of the oil majors and even some banks now quietly use internal carbon prices to manage this risk.

- **R1: Severe weather impacts on mortgage repayments.** Physical destruction of assets due to extreme weather will impact on homeowners' ability to repay loans. If properly insured however, all property losses associated with these events are temporary.

- **A1: Water scarcity.** We can expect that increasing local droughts due to climate change will result in water supply interruption, with agriculture the industry most affected.

In order to mitigate these risks, we suggest that RBS consider implementing the following measures;

F1: Reputational damage from fossil finance
1. Reduce investment in the most the controversial carbon-intensive industries.
2. Price loans to fossil fuel industries in proportion to their reputational risk to RBS.
3. Lease office space within high energy performance buildings and facilitate 'green' business work practices.
4. Leverage 'green' business practices and investments in the media to foster a positive social image.

C1/R2/A2: Rising utility and food prices
1. Inform clients of the financial and security of supply advantages of high energy efficiency.
2. Analyse heavy utilities users' solvency against large price rises and resource rationing.
3. Price the risk of energy and food price increases into loans.
4. Consider the effect of food shortages and price increases on political instability in developing regions.

E4 : Higher carbon prices
1. Adopt an internal carbon price for business decisions aligned with social cost rather than statute.
2. Recommend that clients undertake to do the same.

R1: Severe weather impacts on mortgage repayments
1. Develop a mortgage holiday protocol based on public relations and total repayment advantages.
2. Make sure that special financial assistance can be communicated clearly to customers and the media.

A1: Water scarcity
1. Develop protocols for assessing the regional effects of climate change on agriculture (and other industries), and gauge individual clients' exposure to these.
2. Inform clients of security of supply advantages of high water efficiency investments in dry regions.

In addition to the aforementioned risks, impacts of climate change will also generate opportunities for RBS. We believe the following opportunities related to climate change will have the most potential for RBS.

1. Infrastructure finance
2. Renewables finance
3. Rising food and agricultural land prices
4. Shale gas investment as a low-carbon bridge
5. Energy efficiency investment and building retrofitting
6. Positive social image as competitive advantage
7. Industry initiatives directing capital towards environmentally sustainable economic activities

Overall, our broad conclusion is that climate and environmental risk is present and rising in the financial sector. While there is some potential for low-probability high-gravity events, our view is that these are likely to affect a relatively small part of the RBS lending portfolio over the next decade.

1. Introduction

Climate change looks set to create significant risks and challenges for financial markets, and banks in particular. In this report we discuss relevant key climate and environmental risks and highlight ways in which RBS can factor climate change and other related environmental factors into account in developing business strategies, pricing corporate loans, and entering new markets and geographies. Our focus is mainly upon risks, but also opportunities, that may arise in the coming decade. At RBS's request, we have focused on lending, rather than managed or proprietary investments, within the property (14.5% of lending), energy (2.8%), agriculture (3.0%) and transport (5.5%) sectors, given that these are the largest sectors most likely to be hit by climate change. From a geographical perspective, we have focused on the United Kingdom in particular, but also the USA and to a lesser extent Europe and Asia.

The fact that environmental challenges involve adverse externalities for corporations and society is not new. Climate change, in particular, imposes material risks to corporations, economies, and markets. In order to remain sustainable in the long-run, corporations have to take into account the environment and its effects on business. Companies who do so may gain a competitive advantage vis-à-vis competitors who are not well prepared for the upcoming environmental and climate change challenges (see Porter and Kramer, 2006). In particular, research documents that firms which have better sustainability policies or environmental management systems in place perform, on average, better than their counterparts (see, for example, Klassen and McLaughlin, 1996; King and Lennox, 2002; and Guenster et al, 2011). Banks are also affected by environmental externalities and climate change, including through their lending portfolios.

Specific risks relevant to RBS are discussed in this research report. They touch upon the most recent climate change research and point to the most important environmental development and climate change risks. They underline the need for RBS to more strictly incorporate climate change into their business model.

This report is structured as follows. In section 2, we present an overview of the key climate change and environmental trends, and briefly consider some of the loan pricing implications for RBS. In section 3, we highlight the most salient environmental risks to the financial system and to RBS. Specifically, we investigate physical risks, regulatory and policy risks, as well as a discussion of the current and future banking regulation. Section 4 provides a detailed sector-by-sector analysis of the most important business sectors to RBS and their exposure towards climate change, namely; commercial property, residential property, energy, transport, and agriculture. Section 5 of this report concludes by stressing the most important implications of climate change for RBS. The main report is accompanied by a detailed appendix which includes further information and illustrations with respect to climate change which are beyond the scope of the main text.

2. Overview of Climate Change and Environmental Trends

This section reviews environmental and climate trends at a macro level. We start with an examination of the overall evolution of so-called 'loss events' from extreme events which are related to climate change. Research by insurance companies reveals that the number of loss events has increased substantially of the last couple of decades.

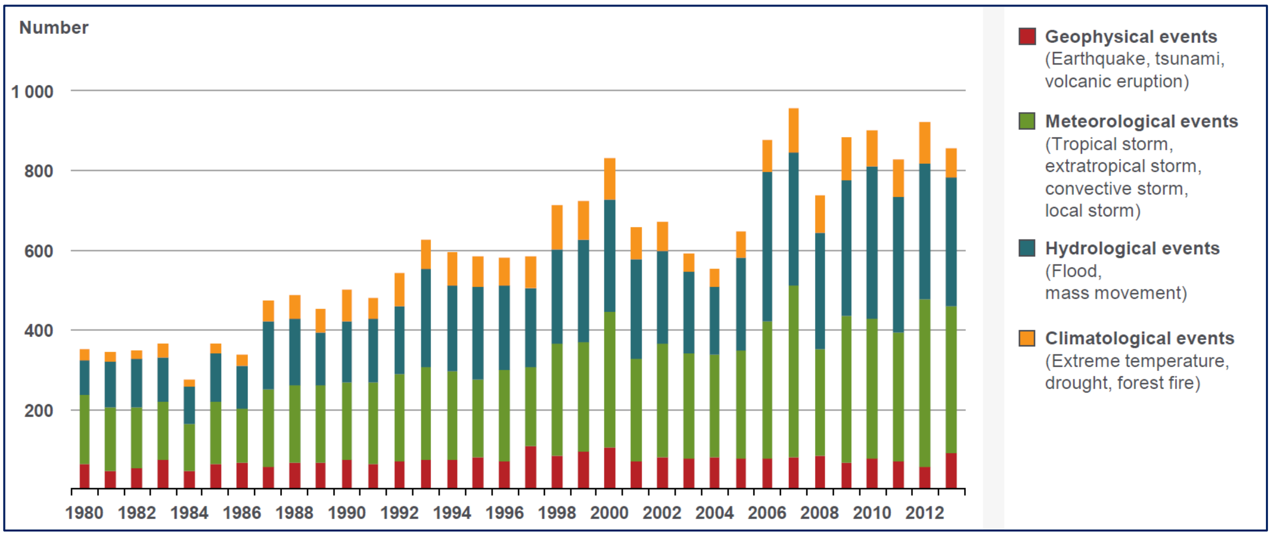


Figure 2 - Loss Events Worldwide 1980-2013; Number of events.
Source: Munich RE (2014).

Figure 2 reveals that while the number of geophysical events (e.g. earthquakes and volcanic eruptions) has stayed relatively constant over time, the number of climate-related loss events due to storms (meterological events), floods (hydrologic events) and extreme temperatures (climatological events) has been rising. The number floods and storms significantly exceeds the number of extreme temperature events.

Taking a more long-term perspective, research documents that the number of natural disasters has increased almost exponentially over the last century, as shown in Figure 3, until a more recent flattening out of the profile, mirroring the current "pause" in atmospheric warming.

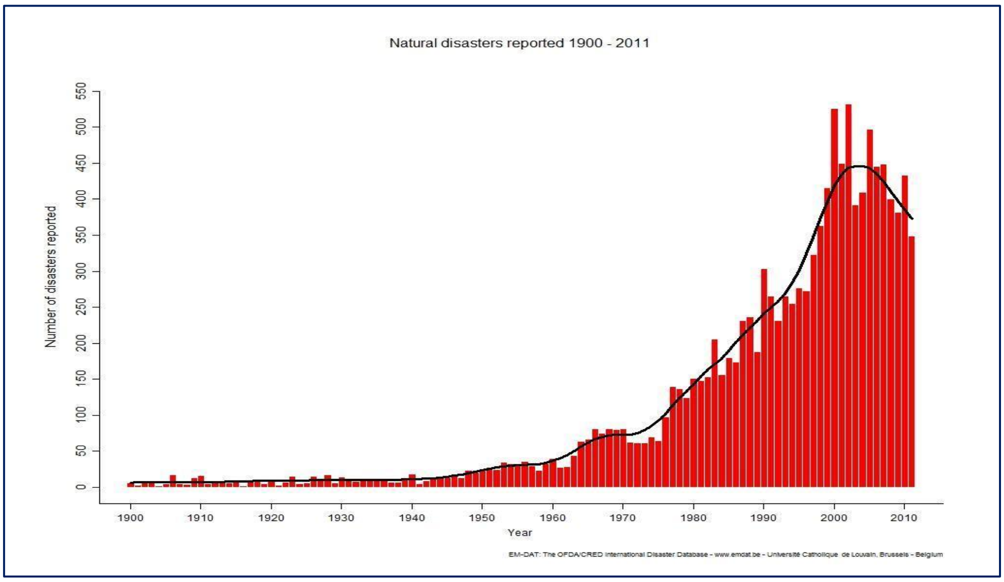


Figure 3 - The number of natural disasters reported from 1900-2011.
Source: EM-DAT.

Of course, these extreme events and natural disasters do occur in different geographical regions more frequently than in others. Research by Münchener Rückversicherung (Munich Re) for the year 2013 shows (represented in Figure 4 below) that there were a total of 880 loss events worldwide. One sees a clear clustering of the most extreme events taking place in North America, Europe, and Asia. In absolute terms, there are fewer loss events in South America and Africa.

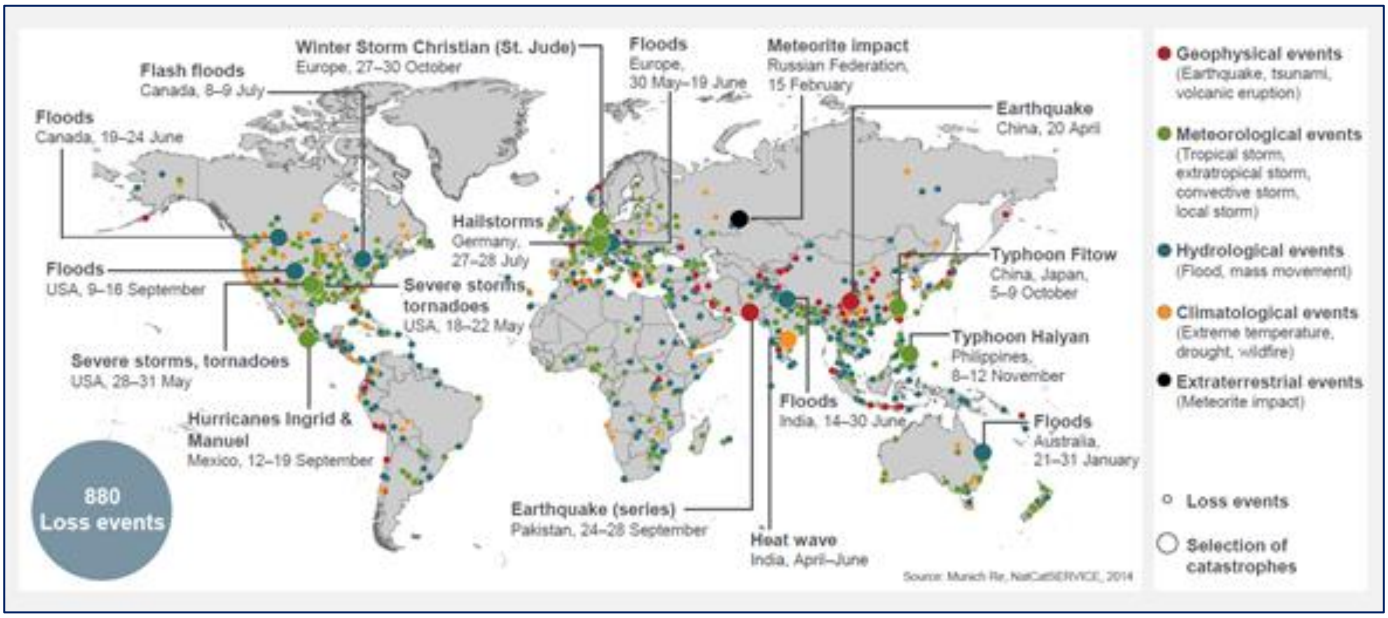


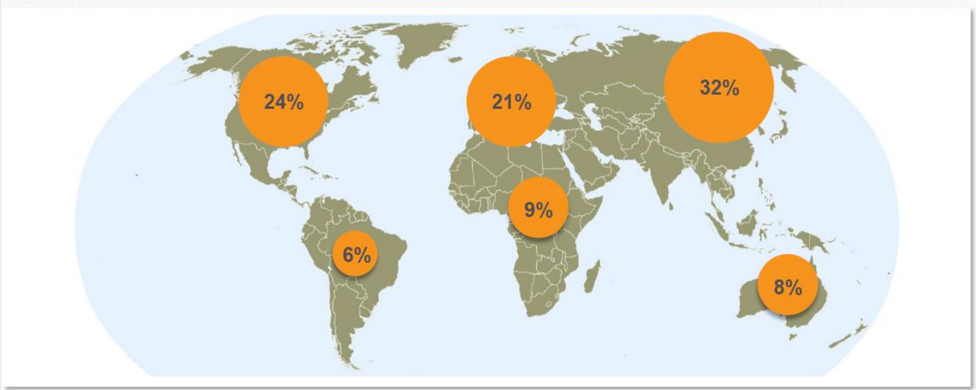
Figure 4 - Loss Events Worldwide 2013.
Source: Munich RE (2014).

According to Munich Re, overall there were 880 natural disasters in 2013. This number is slightly below the one reported for 2012, but well above the average number for the last 30 years. On average, the number of natural disasters has been increasing over time. More information on the absolute numbers of extreme events is provided in Figure 5.

	The figures of the year 2013	The figures of the year 2012	Average of the last 10 years 2003-2012 (Losses adjusted to inflation based on country CPI)	Average of the last 30 years 1983-2012 (Losses adjusted to inflation based on country CPI)
Number of events	880	920	790	630
Overall losses in US$ m	125,000	173,000	184,000	128,000
Insured losses in US$ m	31,000	65,000	56,000	32,000
Fatalities	20,000	10,000	106,000	56,000

Figure 5 - Loss Events in 2013.
Source: Munich RE (2014).

Returning to the geographical dispersion of natural disasters, Figure 6 alludes to the fact that the vast majority of natural disasters between 1980 and 2012 occurred in the Northern hemisphere, especially in North America and Asia. In Europe, the number of significant natural events was also very high with 4,400 taking place over the investigated time period.



Continent	Number of events
America (North and South America)	6,300
Europe	4,400
Africa	1,900
Asia	6,800
Australia/Oceania	1,600

Figure 6 - Natural Catastrophes Worldwide 1980-2012: 21,000 events - Percentage distribution by continent.
Source: Munich RE (2014).

2.1 Overall economic and insured losses

For financial market participants, such as insurance companies and banks, it is more relevant what the economic magnitude of the losses of these events actually is. Therefore, the following three figures have been incorporated into this report to show (1) the economic value of the losses, and (2) the magnitude of those losses which have been insured by insurance companies.

Figure 7 displays the annual overall and insured losses due to natural catastrophes. The first important observation from this graph is the fact that the evolution of economic losses does not mirror the overall evolution of the number of natural disasters (as depicted in Figures 2 and 3). The value of the economic losses due to natural disasters is much more volatile and driven by the most extreme events. This idea is also supported by Figures 8 and 10 which provide more information on drivers of annual economic losses.

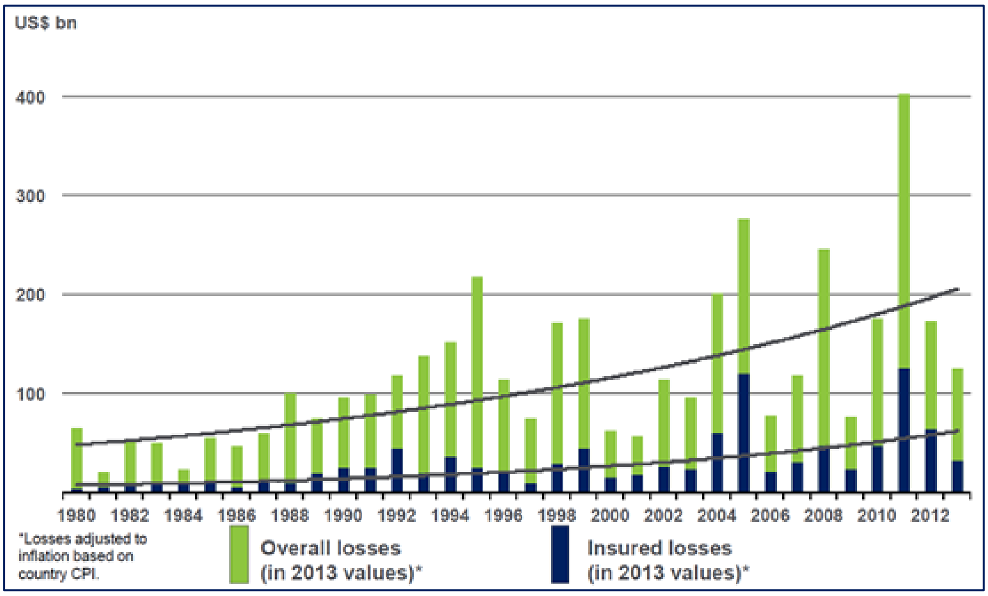


Figure 7 - Loss Events Worldwide 1980-2013: Overall losses and insured losses.
Source: Munich RE (2014).

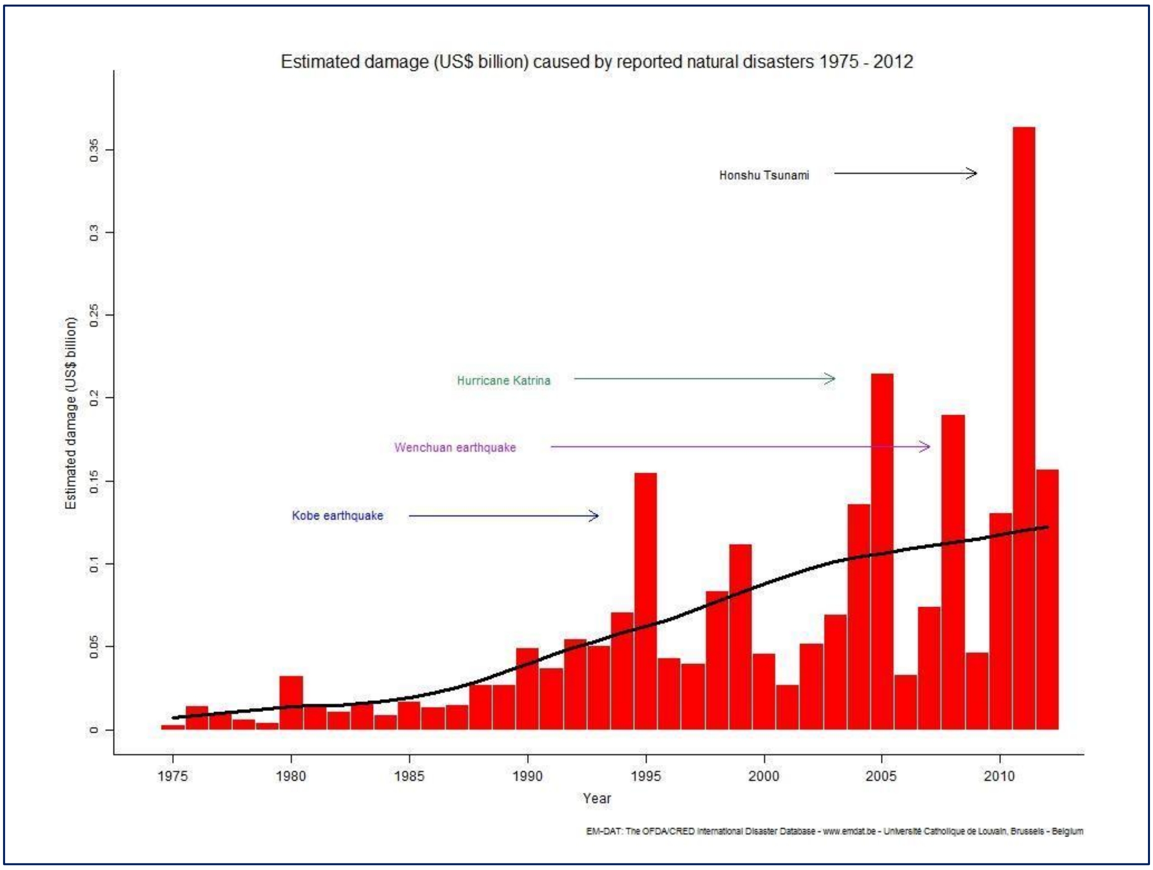
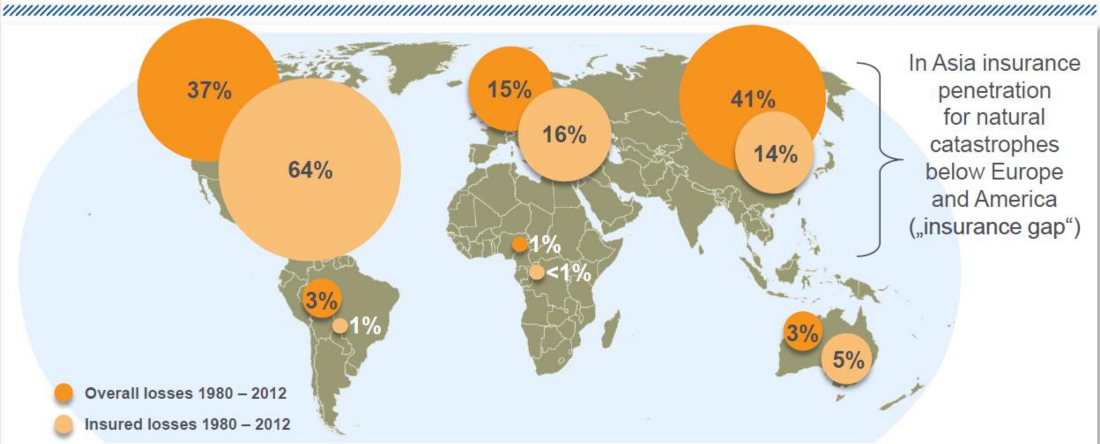


Figure 8 - Estimated damage (US$ billion) caused by reported natural disasters between 1975-2012.
Source: EM-DAT.



Continent / Subcontinent	Overall losses US$bn (US$ 3,800bn)*	Insured losses US$bn (US$ 970bn)*	Fatalities (2,300,000)
America	1,500	630	340,000
Europe	500	160	150,000
Africa	45	2.1	610,000
Asia	1,600	130	1,180,000
Australia/Oceania	105	42	5,900

Figure 9 - Natural catastrophes worldwide 1980-2012: Overall losses, insured losses, and fatalities.
Source: Münchener Rückversicherungsgesellschaft, Geo Risks Research, NatCatService, 2013.

Figure 9 clearly shows that only a small fraction of overall economic losses are insured. This fact has important implications for banks and other financial institutions. Banks providing credit facilities to corporations which are uninsured against losses from extreme weather events are more exposed to risks from climate change and environmental shocks. Economic losses are clustered in North America and Asia, with 37% and 41% of overall losses accruing to these two regions respectively. According to Munich Re, Europe is exposed to only 15% of all economic losses due to natural disasters. Figure 9 also illustrates the fact that in Europe and Asia a mere of 16% and 14% of all economic losses are insured, whereas 64% of losses are insured in America. These differences have significant implications for banks such as RBS. Taking into consideration that losses are far less insured in Europe and Asia, one would expect a higher risk-premium on loan facilities to corporate borrowers domiciling in these particular geographical regions compared with America.

2.2 Economic losses by disaster type and geographical region

The following two Figures illustrate the degree to which each type of natural disaster causes economic damages and in which geographical regions these occur. Figure 10 shows that the majority of loss events are due to meteorological and hydrological occurrences, most significantly, storms and floods. Similarly, the biggest share of the insured loss is as a result of meteorological events implying that most damages related to storms are insured. A much smaller share of the insured losses are related to floods and earthquakes, implying that banks have to take this into account when providing credit facilities to borrowers exposed to these kinds of events and most likely not insured against these risks.

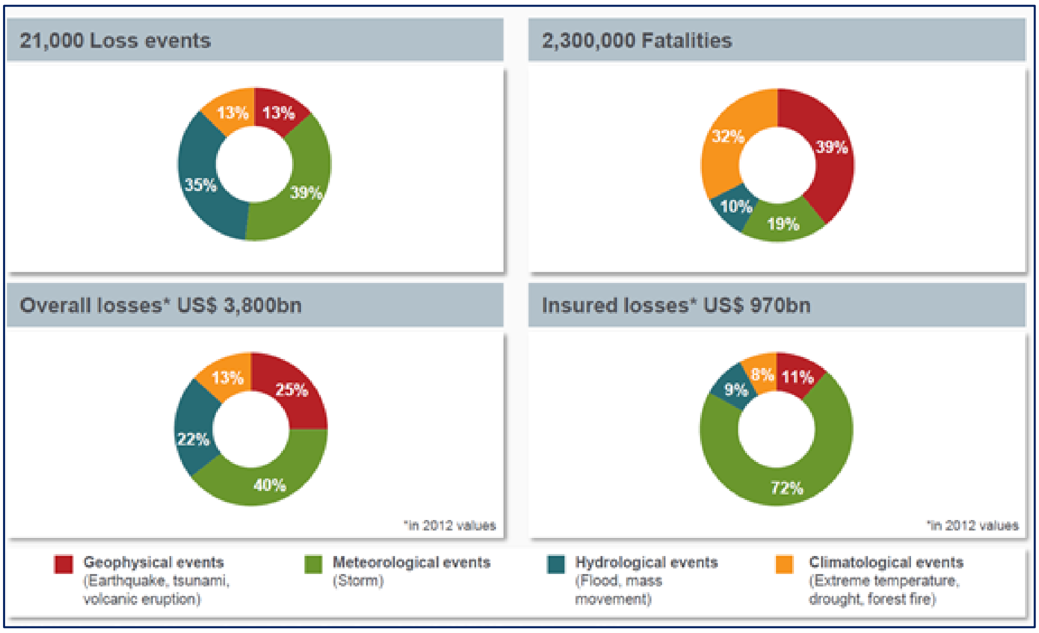


Figure 10 - Natural catastrophes worldwide: Percentage distribution.
Source: Munich RE (2014).

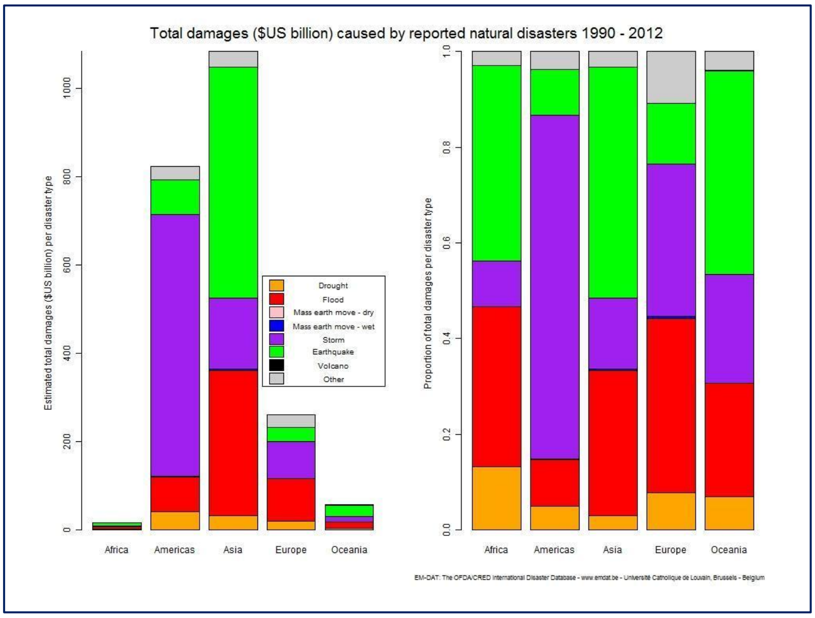


Figure 11 - Total damages ($US billion) caused by reported natural disasters.
Source: EM-DAT.

Figure 11 reveals a similar picture. Relatively speaking, the largest damages in the Americas and in Europe are caused by storms. Floods are apparently also causing significant damage in Asia and Europe, while earthquakes are the biggest source of environmental risks in Africa, Asia, and Oceania. Making borrowers aware of these kinds of risks, by providing new financial products would help reduce the transferred risk to RBS itself. Again, the exposure of borrowers in these geographical regions to these types of natural disasters calls for a much stricter integration of environmental risks into the pricing models of corporate and private loans.

2.3 Loan Pricing Implications for RBS

This overview of risks leads to an important implication for RBS. When providing loans to corporate borrowers (or even individuals), RBS should take into account information on climate change and environmental disasters for the particular geographical region in which the borrower resides. This information is relevant to the pricing of the loan spread, given the possibility of default or delayed repayment of the loan facility caused by extreme weather events. A great deal of empirical research (see overview table below) shows that firms with superior environmental management systems in place have significantly lower loan spreads or better ratings, because superior ESG quality helps reduce the negative effect of potential loss events. The reverse relationship has also been documented in the literature, with exposed to many environmental concerns paying significantly higher loan spreads and suffer from also having lower credit ratings.

Study authors	ESG measure	Results
Bauer and Hann (2010)	Environmental performance	Firms with proper environmental management systems exhibit significantly lower loan spreads.
Chava (2011)	Environmental performance	Firms exposed to a lot of environmental concerns do have to pay significantly higher interest rates on their loan facilities.
Goss and Roberts (2011)	Corporate social responsibility measure	Firms which have many CSR concerns (i.e. a bad CSR quality) pay on average between 7 and 18 basis points more interest.

Figure 12 – Studies investigating the relationship between ESG quality (in particular corporate environmental performance) and costs of bank loans.

In fact, there is not only evidence on the relationship between corporate environmental performance and the costs of bank loans, but also on other ESG factors and their relation to bond ratings and bond yields. The general conclusion from the literature on ESG and its effect on corporate costs of debt is that better ESG quality leads to lower costs of debt financing – be it in the form of better bond ratings and thus lower spreads, or lower interest payment on bank loans. Exemplary studies are by Attig et al. (2013), Schneider (2011) or Cremers et al. (2007). The reason for this relationship is often the fact that corporations with good ESG quality are well-prepared for externalities related to the environment, to the social and governance domain of a corporation.

From our point of view, we think that credit rating agencies are also aware of ESG matters when establishing their corporate ratings. However, the most prevalent factor is the governance dimension of ESG. Though environmental and social issues are also increasingly into account when setting up corporate ratings, we think that they should also be explicitly priced into loan facilities and bond prices.

Hence, we recommend that RBS consider explicitly pricing in environmental and climate change risks in order to account for the externalities imposed on corporate borrowers in the longer-term. We also anticipate that this will eventually become the standard in the banking industry, and that also extra-financial information on the social and especially environmental quality of borrowers will be taken into account in the pricing process of corporate loans. Incorporating this information works as a risk management tool, and might become an obligatory feature of every credit assessment in future iterations of the Basel agreements.

3. Risks to the Financial System and to RBS

In the remainder of this report, we discuss several important types of risks relevant to RBS and the financial market. In particular, we discuss physical climate and environmental risks, climate policy risks, and regulatory risks.

The following graph is taken from a study of the effects of climate change on the banking industry by SAM and ETH Zurich and succinctly illustrates the relevant risks to different asset classes arising from different sources.

Asset class	Climate Risk	Resulting from…
Equities	Regulatory risks	Efforts by governments to regulate greenhouse gas emissions
	Physical risks	Physical impact of climate change including droughts, floods, storms and rising sea levels
	Litigation risks	Lawsuits against companies and sectors responsible for large amounts of greenhouse gas emissions (cf. tobacco and asbestos industries)
	Competitiveness risks	Higher costs and lower profit margins due to reactive approach to climate change
	Reputational risks	Backlash from consumers in markets where the public is concerned about climate change
Property	Regulatory risks	Likely future focus of policy due to low energy performance of buildings
	Physical risks	High exposure to physical impacts of climate change (e.g. flooding, wind damage)
	Competitive risks	Rising energy prices
Government bonds	Physical impacts	Exposure of low-lying countries and islands, many of which are in developing countries; limited capacity to respond; impact on public finances and currency movements
Alternatives, private equity, carbon markets	Competitiveness opportunities	Major investments in renewable energy and related technologies; development of carbon trading markets

Figure 3 Climate risks of selected asset classes (assembled from Mercer Investment Consulting 2005)

Figure 13 – Climate Risks of Selected Asset Classes
Source: Furrer et al. (2009).

3.1 Physical Risks

Having examined the environmental disasters and risks affecting the financial sector over the past 30 years we now turn to a discussion of particular risks which may become relevant for RBS in the near future.

Hurricanes and Tornados

Hurricanes impose important risks to corporations, people, and the environment in certain regions. The following information in this paragraph illustrates these risks. The consensus of projections and reports dealing with hurricanes/tropical cyclones and climate change indicates that the average number of these phenomena is not increasing but they are going to be stronger. That is, they will be characterized by higher wind speeds and precipitations. This will increase the destructive potential of such phenomena. Moreover the greatest losses for tropical cyclones are associated with those in categories 3, 4 and 5, therefore the increase in total damage and losses should be expected to be greater.

The economic effect of hurricanes and storms on major metropolitan areas is represented in the following chart. A similar picture is revealed for coastal risks: in major areas in Asia, such as Japan and China, but also in Indonesia and the Caribbean Islands the economic effect (as measured in terms of the value of working days lost) is highest. This has implications for the regional residential and commercial property markets.

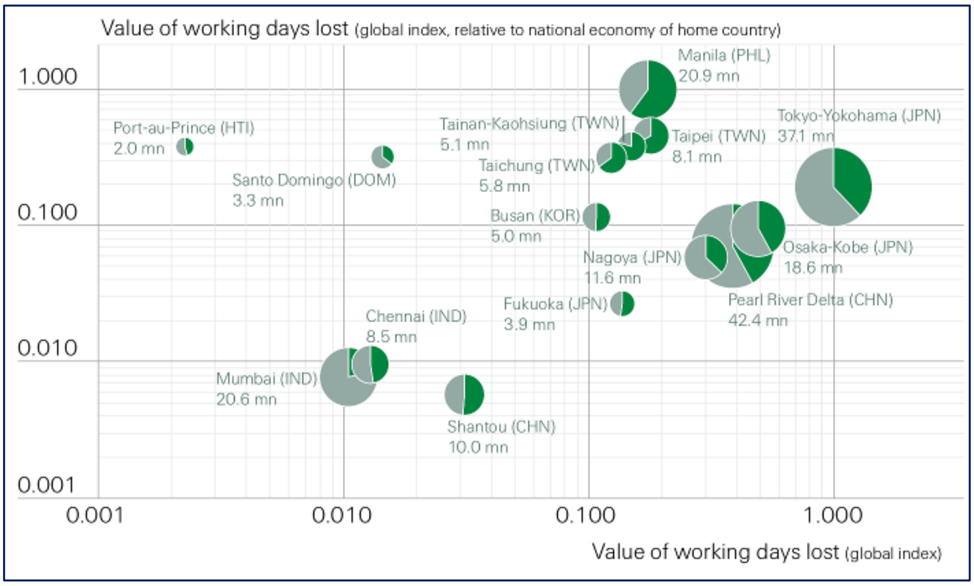


Figure 21- Top metropolitan areas at risk from storms.
Source: Swiss Re (2014).

The size of the bubble represents the number of inhabitants living in the metropolitan area and the green wedge is the share of inhabitants potentially affected. The x-axis represents the value of working days loss per city and the y-axis shows the value of working days lost per city in relation to the national economy.

Thus far, the report has presented projections into the future and recent evidence on the effect of storms on the economy. Taking a longer-term perspective, one finds that for the Atlantic Basin, the number of Hurricanes has increased recently and that there was not a single year without Hurricanes since 1851. This is shown in the following figure. Hence, we argue that major storms such as Hurricanes impose a visible, predictable, and major risk to the economy, and major metropolitan areas which must be taken into account in the credit assessment for banks when giving out loans to individuals or corporations.

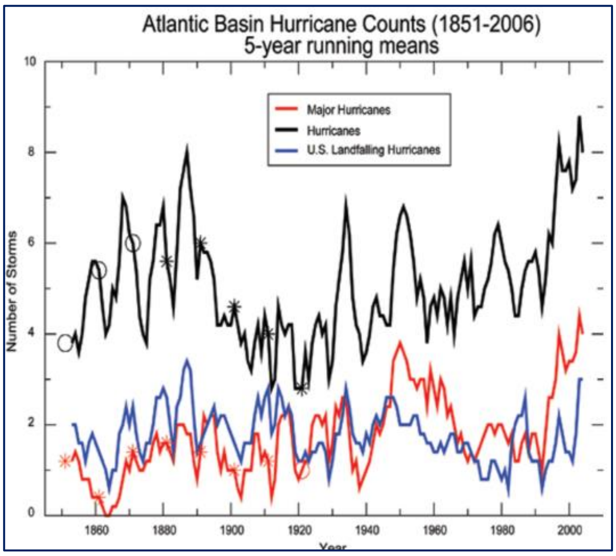


Figure 22 - Atlantic Basin Hurricane Counts (1851-2006).
Counts of total North Atlantic basin hurricanes (black), major hurricanes (red), and U.S. landfalling hurricanes (blue) are based on annual data from 1851 to 2006 and smoothed (using a 5-year running mean). Asterisks on the time series indicate years where trends beginning in that year and extending through 2005 are statistically significant (p=0.05) based on annual data; circles indicate non-significant trend results (data obtained from NOAA's Oceanographic and Meteorological Laboratory: http://www.aoml.noaa.gov/hrd/hurdat/ushurrlist18512005-gt.txt).
Source: Karl et al. (2008)

It is also illustrative to examine the absolute damages caused by several different hurricanes in the U.S. over the last two decades (data in US billion dollars):

Sandy (2012)	Irene (2011)	Katrina (2005)	Rita (2005)	Charley (2004)	Allison (2001)	Andrew (1992)
$50bn	$15bn	$113.4bn	$12.6bn	$17.2bn	$12.5bn	$58.6bn

Figure 23 - Total damages from hurricanes in US billion dollars
Source: Forbes (2012), own representation.

Clearly the economic damages and losses arising out of tropical storms can be huge, and that the increasing probability of extreme storms, especially tornados and hurricanes should be considered when finance is extended.

Coastal Risks

It is estimated that for the world's largest 136 coastal cities average global flood losses in 2005 are estimated to be approximately US$6 billion per year, increasing to US$52 billion by 2050 with projected socio-economic change alone. With climate change and subsidence, present protection will need to be upgraded to avoid unacceptable losses of US$1 trillion or more per year. Even if adaptation investments maintain constant flood probability, subsidence and sea-level rise will increase global flood losses to US$60–63 billion per year in 2050''.
The following two figures illustrate which cities will be most prone towards sea-level rise and coastal risks defined as average annual losses (AAL). AAL is highest for cities located around the Mediterranean Sea, cities on the Caribbean Islands, and China.

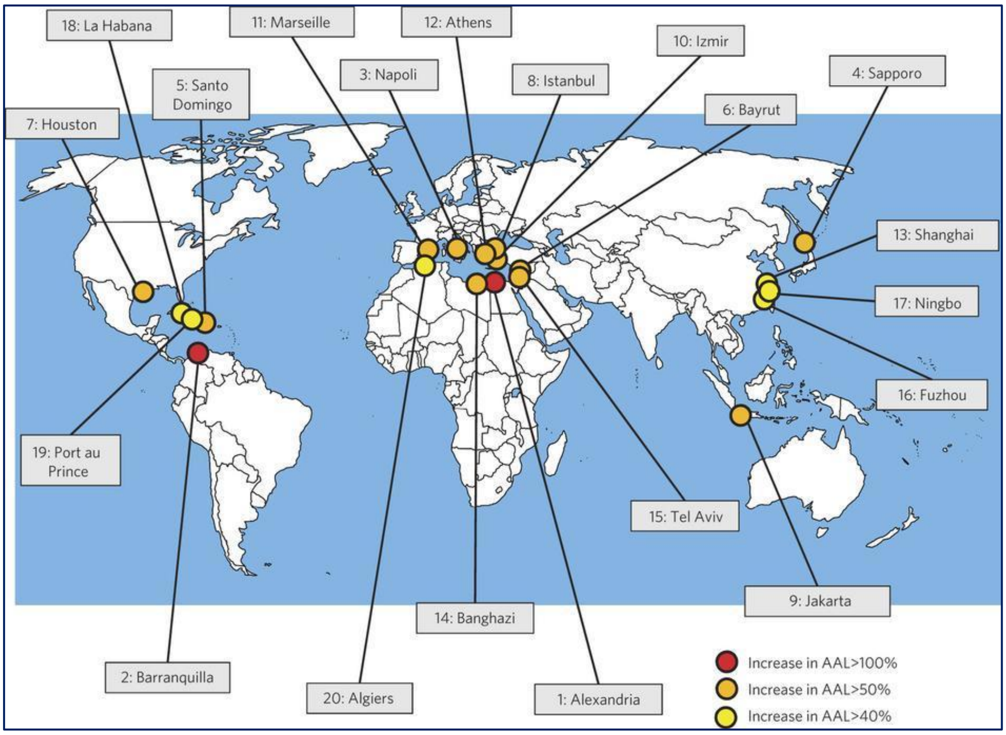


Figure 19.
The 20 cities where average annual losses (AAL) increase most (in relative terms in 2050 compared with 2005) in the case of optimistic sea-level rise, if adaptation only maintains present defence standards or flood probability (PD).
Source: Hallegate et al. (2013).

Urban agglomeration	Scenarios with socio-economic change alone (SEC): AAL (US$ million)	Scenarios with socio-economic change alone (SEC): AAL (percentage of city GDP)	Scenarios with socio-economic change, subsidence, sea-level rise and adaptation to maintain flood probability (scenarios SLR-1, and adaptation option PD): AAL (US$ million)	Increase in AAL compared with 2005 (%)	AAL (percentage of city GDP)
Guangzhou (S)	11,928	1.32%	13,200	11%	1.46%
Mumbai	6,109	0.47%	6,414	5%	0.49%
Kolkata (S)	2,704	0.21%	3,350	24%	0.26%
Guayaquil (S)	2,813	0.95%	3,189	13%	1.08%
Shenzen	2,929	0.38%	3,136	7%	0.40%
Miami	2,099	0.30%	2,549	21%	0.36%
Tianjin (S)	1,810	0.24%	2,276	26%	0.30%
New York—Newark	1,960	0.08%	2,056	5%	0.08%
Ho Chi Minh City (S)	1,743	0.74%	1,953	12%	0.83%
New Orleans (S)	1,583	1.21%	1,864	18%	1.42%
Jakarta (S)	1,139	0.14%	1,750	54%	0.22%
Abidjan	826	0.72%	1,023	24%	0.89%
Chennai (Madras)	825	0.12%	939	14%	0.14%
Surat	905	0.25%	928	3%	0.26%
Zhanjiang (S)	806	0.50%	891	11%	0.55%
Tampa—St. Petersburg	763	0.26%	859	13%	0.29%
Boston	741	0.13%	793	7%	0.14%
Bangkok (S)	596	0.07%	734	23%	0.09%
Xiamen (S)	572	0.22%	729	27%	0.29%
Nagoya (S)	564	0.26%	644	14%	0.30%

Figure 20.
The 20 cities with the highest loss in 2050, assuming scenario SLR-1 (optimistic sea level rise + socio-economic changes and subsidence) and adaptation option that considers constant flood probability.
Source: Hallegate et al. (2013).

Increasing floods, cumulative precipitation and droughts

Increasing floods (extreme *daily* precipitation) and extreme cumulative *seasonal* precipitation (low or high) represent a major risk for people, infrastructure, agriculture and management and security of power supply. There is empirical evidence of an increase in the number of these events for the last 50 years and probability of occurrence is expected to continue increasing in the coming years. Associated risks are landslides, increased sedimentation and dredging needed for ports, dams, lower quality water for utilities and bottlers and greater costs of filtering water and damp/mold damage.

The following two figures illustrate the impact that cumulative precipitation and flooding can have on cities and major geographical regions.

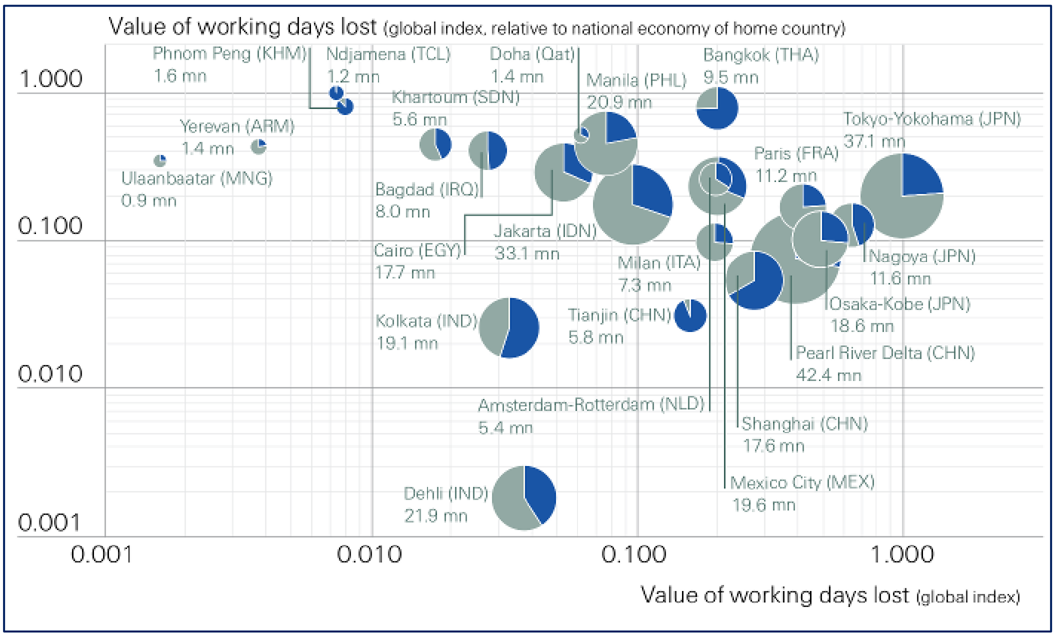


Figure 15 - Metropolitan areas at risk from river flooding.
The size of the bubble represents the number of inhabitants living in the metropolitan area, the blue wedge is the share of inhabitants potentially affected. X-axis represents the value of working days loss per city, and the y-axis shows the value of working days lost per city in relation to the national economy.
Source: Swiss Re (2014).

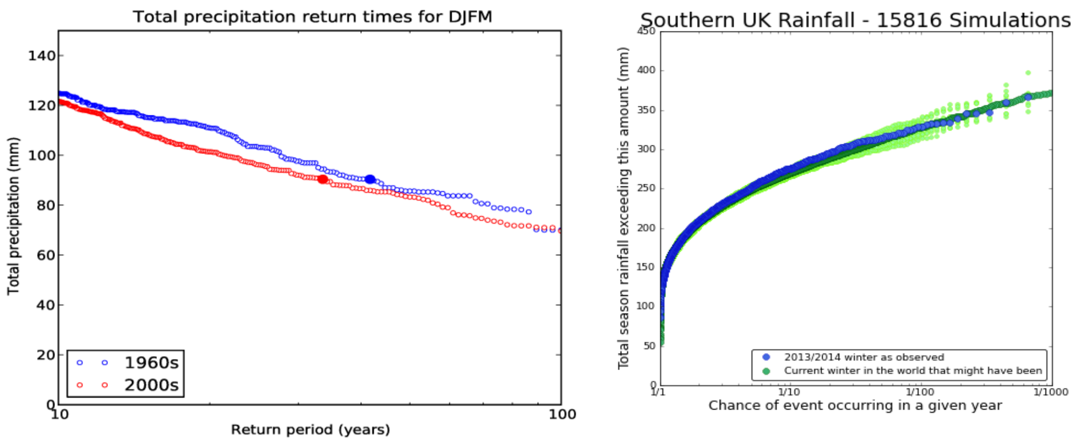


Figure 16 - Changes in the return time of extreme droughts for the Iberian Peninsula (Left) and extreme seasonal precipitation for the UK (Right).

(Left) Comparison of the return period in 1960s vs. 2000s for an extreme winter (December to March) drought in the Iberian Peninsula. An increase of approx. 25% in the chance of such a drought is observed Source: (Peterson et al. (2013).

(Right) Chance of occurrence of extreme cumulative precipitation for winter (December to February) in the UK. Source: ClimatePrediction.net.

It is clear that we can expect increasing number of high precipitation events in the UK and droughts in the Iberian Peninsula. The exposure to floods, however, is not the same everywhere. The IPCC has estimated the following damages from flooding to be realized in the 21st century.

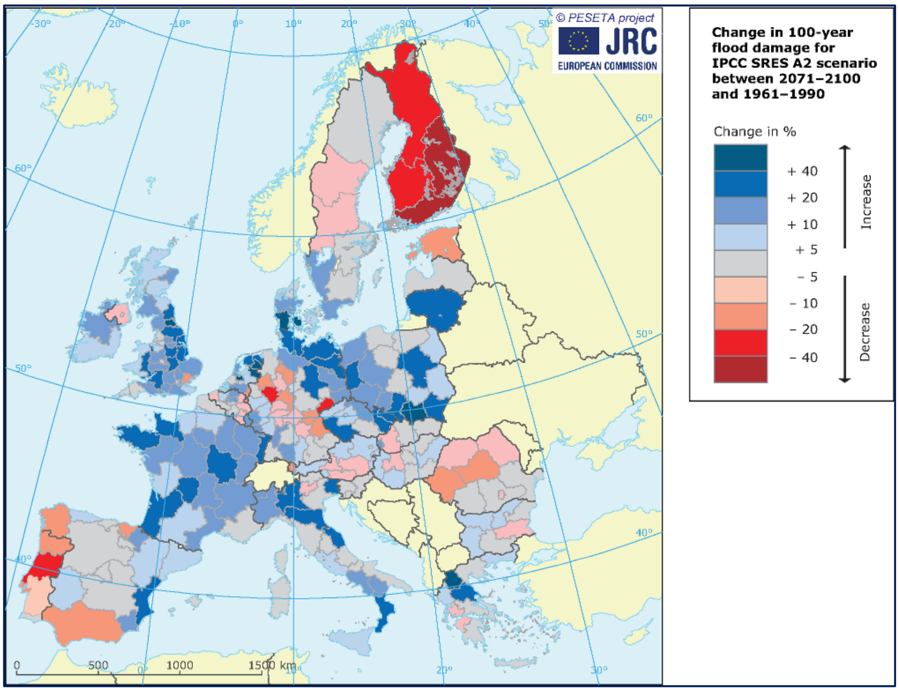


Figure 17 - Change in 100-year flood damage for IPCC SRES A2 scenario.
Source: Ciscar (2009).

This projection predicts that several regions in Europe will be strongly affected by flood damages. In particular, the United Kingdom, France, Germany, and Poland will be exposed to a rise of up to 40% in flood damages. By contrast, Finland and Portugal will experience a decrease in flood damages that might, conversely, expose them to droughts and water scarcity.

The European Commission has also estimated the costs of river flooding for several European regions. Under different assumptions, the European Commission came to the conclusion that for the EU as a whole, even in the best case scenario, the welfare loss would be 2,958 million Euros.

	Worst case	Reference	Best case
Northern Europe	-493	212	-26
UK & Ireland	-13,462	-2,965	110
Central Europe north	-3,702	-469	-383
Central Europe south	-9,818	-3,210	-57
Southern Europe	-4,489	-1,037	-2,603
EU	-31,965	-7,469	-2,958

Figure 18- Welfare impacts of river floods in worst, reference and best cases from twelve climate models considering the same emission scenario and economic model (2005 million Euro).
Source: Hallegate et al. (2013).

These projections imply that banks have to take flooding as a major credit risk into account. Damages at production plants, infrastructure, or other crucial supply chain components can be so extensively that whole production processes have to be closed down, implying financial losses for the affected firms which in turn will also affect the corporation's ability to repay their loan and to serve interest payments.

On top of the implications for the industrial sector, floods also have important implications for the residential and commercial property markets. These are going to be discussed in a later section.

Heat-waves

Heat-waves have an impact on power plant operations, potentially raising the temperature of water coolant above acceptable limits. The power outages that result can have important financial effects on both energy firms and their customers. The reported number of unexpected stoppages of nuclear and thermal power plants has increased in the last years.

There may also be other economic losses associated with heat-waves. For example, during the July-September 2010 heat-wave in Russia, total losses due to burned down homes, agriculture, forestry and infrastructure were estimated at US$3.6bn.

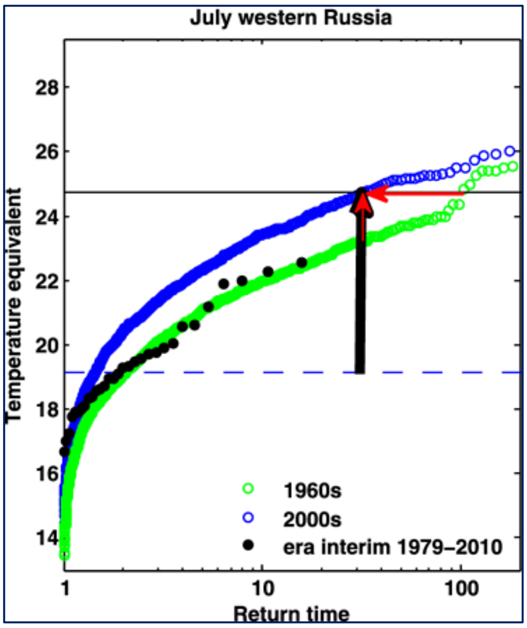


Figure 14 - Return time of extreme temperatures observed during Summer 2010 in Russia - indicated by intersection of red arrows. The green line shows the return period for a given temperature according to the climatic conditions existing in the 1960s and blue the 2000s. The difference between the two series shows how the probability of the Russian heat-wave of 2010 has increased. In the 1960s such a heat-wave would occur once each 90 years, but for current conditions we observe one each 30 years. Source: Otto et al. (2012).

Cold Snaps

The probability of extreme cold conditions, in some locations, may be expected to increase over the coming decades. A recent example is this past winter in the the U.S.A. Phenomena such as the well-known changes in the jet stream contribute to these extreme conditions. These events cause obvious disruptions to transport, increase energy demand and production (availability of water with the right temperature) and create problems for infrastructures and crops. A disruption to a whole sector might also indirectly lead to important adverse effects for banks giving out loans to corporations in those industries.

3.2 Regulatory and Policy Risks

At the international level, the United Nations Framework Convention on Climate Change (UNFCCC) has delivered a clear objective to limit global warming to 2°C. However if the world is to prevent dangerous warming of >2°C, it must cumulatively burn less than approximately 1 trillion tonnes of CO_2. By the mid-1990s we had already used up a third of this allotment, and have now used up just over half of this budget. At current rates of emissions growth we are scheduled to surpass this quota by 2045.

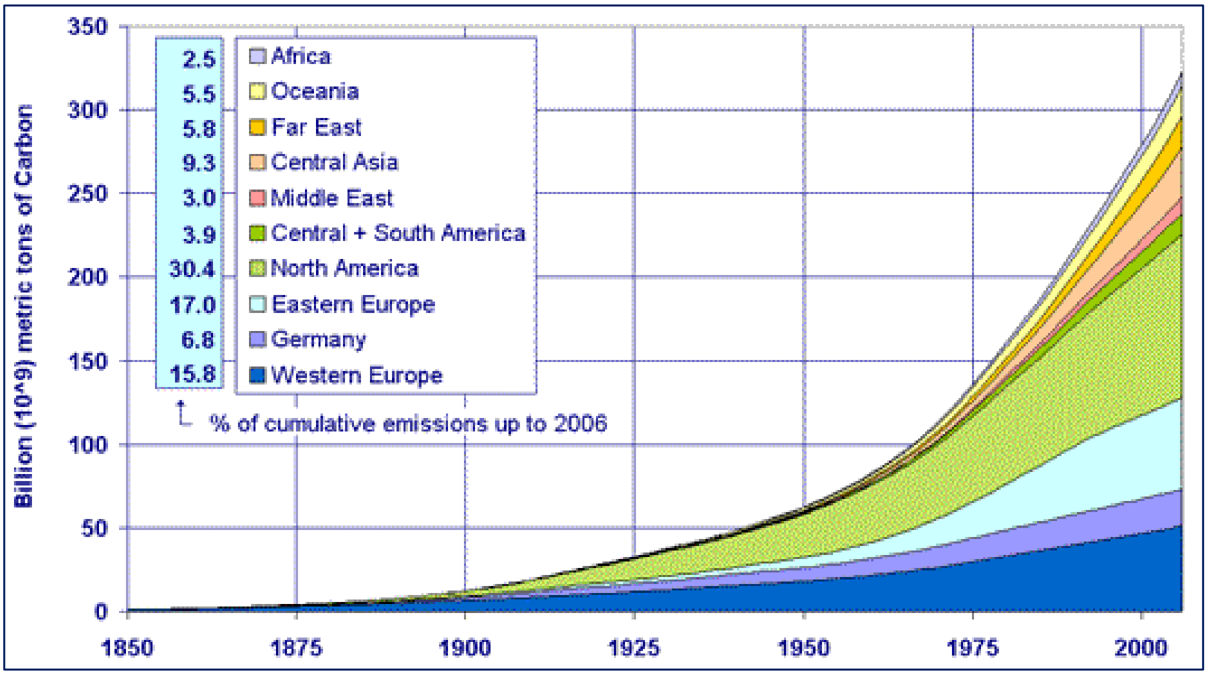


Figure 23 – Cumulative Regional CO2 Emissions (1850-2006)
Source: United Nations Framework Convention on Climate Change

Over the past decade climate change regulations globally have been growing even faster than emissions. According to Globe International, 88% of global CO2 emissions come from 66 countries, and these countries currently have enacted a patchwork of 487 national and regional laws pertaining to climate change, up from <100 in 2002, and <40 in 1997.

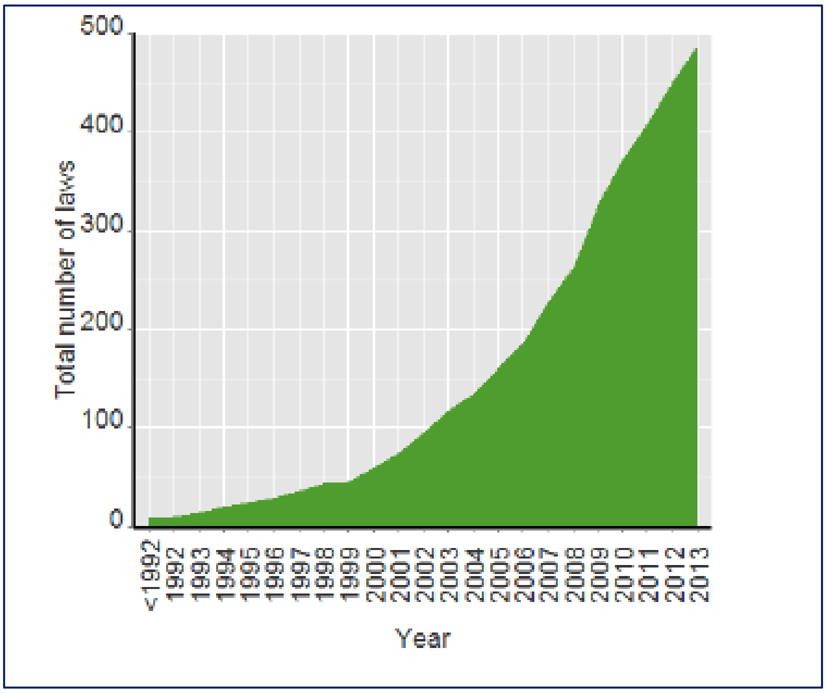


Figure 24 – Cumulative Global Stock of Climate Change Legislation
Source: Nachmany et al. (2014)

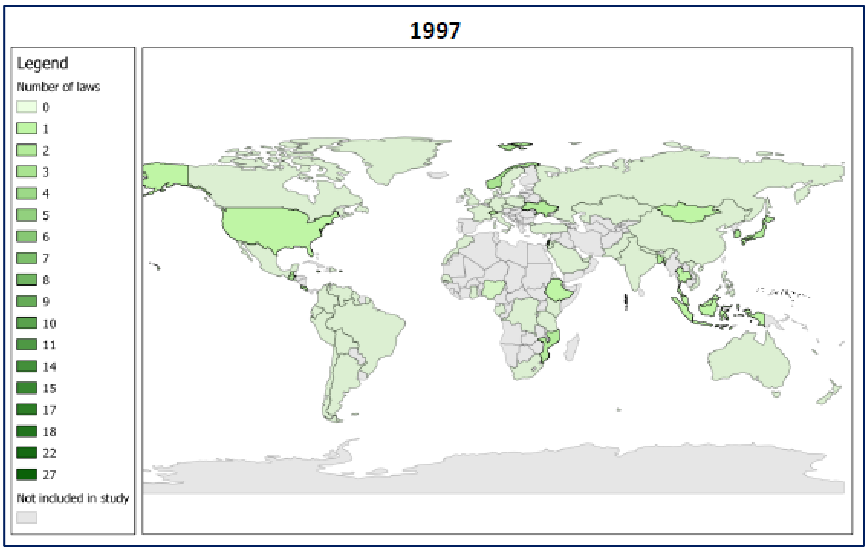


Figure 25 - Number of Climate Change Laws by Country 1997
Source: Nachmany et al. (2014)

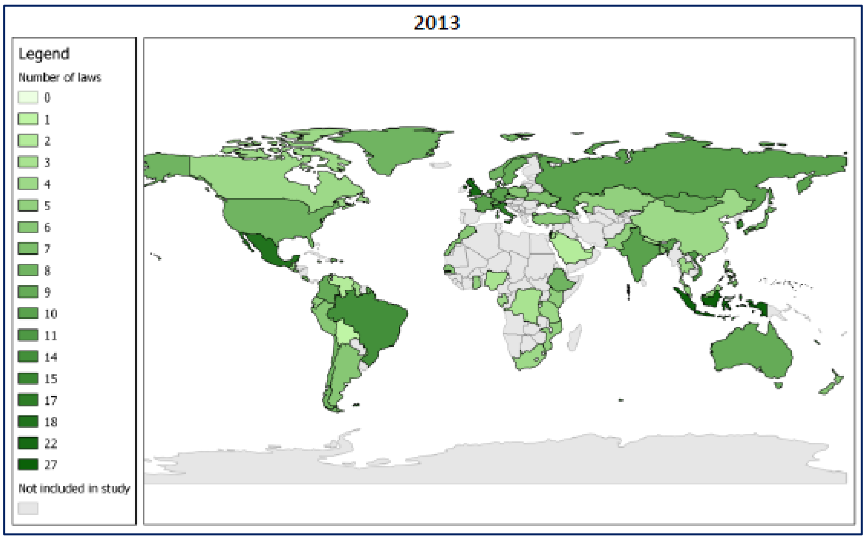


Figure 26 – Number of Climate Change Laws by Country 2013
Source: Nachmany et al. (2014)

Every year these countries produce an average of 30 new climate change laws, and in the past 5 years only three countries have reversed or expressed the intention to reverse significant climate-related legislation (Canada, 2012; Japan, 2013; and Australia, 2014). While effective new policy measures are to be commended, new legislation attempting to deal with climate change also poses a threat to investment risk. In Europe for instance, energy producers such as RWE and GDF Suez have reported operating losses and asset write-downs in the €10bns as a result of subsidised competition with renewables, and utilities as a whole have lost €500bn in market capitalisation since the financial crisis. Over the next 10 years, changes to climate change regulation have far greater potential to drive loan solvency than physical risk - perhaps by several times.

Explicit carbon prices	***Regulatory instruments***
Emissions trading scheme — cap-and-trade	Renewable energy target
Emissions trading scheme — baseline and credit	Renewable energy certificate scheme
Emissions trading scheme — voluntary	Electricity supply or pricing regulation
Carbon tax	Technology standard
Subsidies and (other) taxes	Fuel content mandate
Capital subsidy	Energy efficiency regulation
Feed-in tariff	Mandatory assessment, audit or investment
Tax rebate or credit	Synthetic greenhouse gas regulation
Tax exemption	Urban or transport planning regulation
Preferential, low-interest or guaranteed loan	Other regulation
Other subsidy or grant	***Support for research and development (R&D)***
Fuel or resource tax	R&D — general and demonstration
Other tax	R&D — deployment and diffusion
Direct government expenditure	***Other***
Government procurement — general	Information provision or benchmarking
Government procurement — carbon offsets	Labelling scheme
Government investment — infrastructure	Advertising or educational scheme
Government investment — environment	Broad target or intergovernmental framework
	Voluntary agreement

Figure 27 - Taxonomy of Climate-Related Policies
Source: Carbon Emission Policies in Key Economies (2011), Australian Government

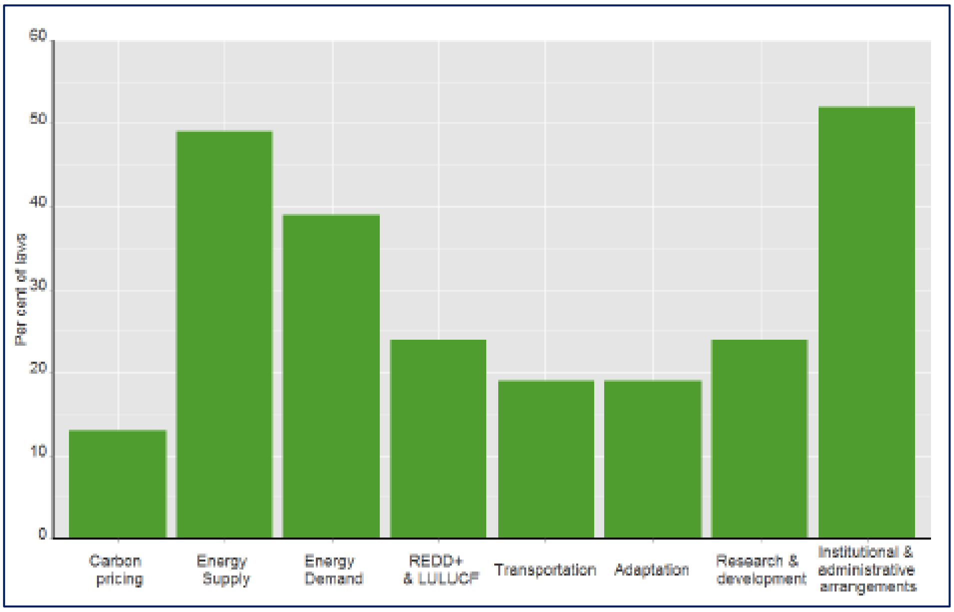


Figure 28 - Percentage of Climate-Related Policies by Category
Source: Globe International, Globe Climate Legislation Study 4th edition

The European Union, including the UK, is the pre-eminent world leader in climate change legislation with the US/Canada, India, and China relative laggards in this regard. Only the EU has binding commitments. The US and Canada have non-binding emissions reduction targets, and China and India will increase emissions for the foreseeable future, but plan to reduce carbon-intensity in the near term. Planned increased efforts by China to combat environmental problems such as particulate air pollution, however, may spur additional measures related to climate change.

International Climate Change Commitments & Major Existing and Potential Laws

	Commitments	Significant Existing Legislation	Potential Legislation 1-10yrs
EU *3rd largest emitter (14% total)*	Binding commitment to progressively reduce emissions 80% below 1990 levels by 2050	EU Emissions Trading Scheme (ETS) Industrial Emissions Directive (2015) EU climate-related expenditure to increase from 7-20% of budget (2014-2020)	ETS price floor (1-10yrs) Agricultural emissions regulation and forest mgmt Coal-fired power ban (1-10yrs) Shale Gas Exploitation (5-10yrs)
UK *10th largest emitter (2% total)*	Part of EU	Part of EU Climate Change Levy Carbon Price Floor (2013) Shale Gas Exploration	Emissions Performance Standard (1-3yrs) Electricity Price Freeze (1yr)
US *2nd largest emitter (18% total)*	Non-binding commitment to progressively reduce emissions 83% below 2005 levels by 2050	Western Climate Initiative ETS (2013) -California only Regional Greenhouse Gas Initiative ETS (2009) - 10 New England States Shale Gas Exploration	ETS geographic and sectoral expansion (5-10yrs) Power plant emissions standard (1-5yrs) Carbon Tax (5-10yrs)
Canada *7th largest emitter (2% total)*	Non-binding commitment to reduce emissions 17% below 2005 levels by 2020	Western Climate Initiative ETS (2014) –Quebec only Carbon Tax (Quebec and British Columbia)	ETS geographic and sectoral expansion (5-10yrs) National Carbon Tax (3-10yrs)
China *Largest emitter (25% total)*	Emissions slated to rise until 2030 Non-binding commitment to reduce CO_2/unit GDP by 40-45% of 2005 levels by 2020	Municipal and Provincial ETS (2013) Green credit guidelines used to ration commercial loans	National Emissions Trading Scheme (3-6yrs) Carbon Tax (5-10yrs) Air quality control (1-5yrs)
India *4th largest emitter (5% total)*	Emissions slated to rise Non-binding commitment to reduce emissions intensity by 20-25% of 2005 levels by 2020	Carbon Tax (US$0.80/tonne) Mandatory 20% biofuel blending by 2017	Emissions Trading Scheme (5-10yrs) Increased carbon Tax (3-10yrs) Improved coal-fired plant efficiency (1-5yrs)

Current global laws are insufficient to prevent ≤2°C warming (3-5°C predicted by centuries end with no additional abatement). As electorates' experience with and perception of this issue changes, we can foresee governments pursuing further legislation to at least attempt to bring the world closer to this goal.

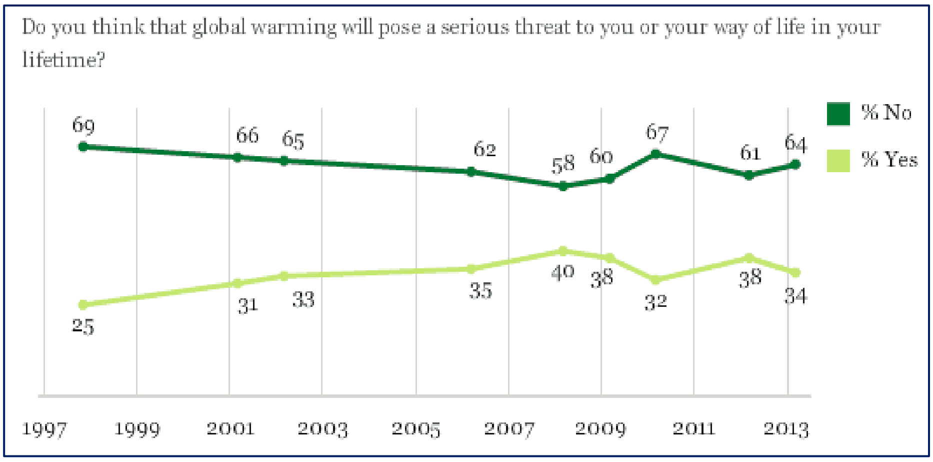


Figure 29 - US Attitudes to Global Warming
Source: Gallup.com

Judging by history, these measures will be enacted primarily at the national scale (although scope for international agreement may arise at Paris 2015). The majority of new policies will also amend or supplement existing regulation, and given the frequent lack of a coherent national central plan, in practice many of these policies may run counter to stated goals. The result is often retroactive regulatory changes.

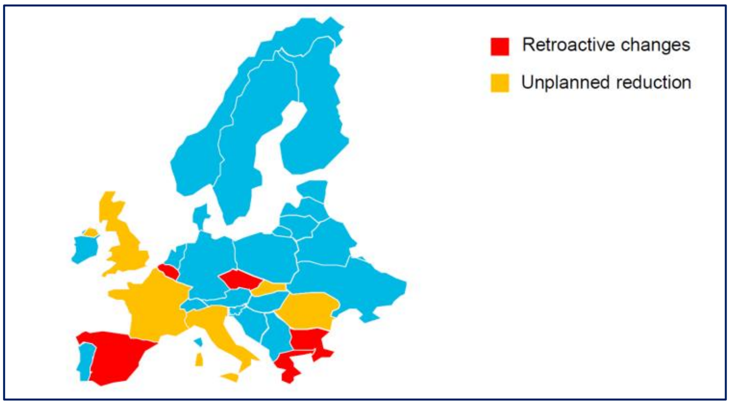


Figure 30 - EU Renewable Energy Subsidy Changes
Source: Bloomberg New Energy Finance 'Global Trends in Clean Energy Investment'

In anticipation of greater regulatory restriction and continuing public attitude shifts, many corporations utilise an internal carbon price significantly in excess of statutory requirements.

Consumer Discretionary	
	Delphi Automotive Plc
	Walt Disney Company, $10-20 **
Consumer Staples	
	ConAgra Foods, Inc.
	Wal-Mart Stores, Inc.
Energy	
	Apache Corporation
	BP, $40
	Chevron Corporation
	ConocoPhillips, $8 – 46
	Devon Energy Corporation, $15
	Exxon Mobil Corporation, $60
	Hess Corporation
	Royal Dutch Shell, $40
	Total, $34
Financials	
	Wells Fargo & Company
Industrials	
	Cummins Inc.
	Delta Air Lines
	General Electric Company
Information Technology	
	Google Inc., $14
	Jabil Circuit, Inc.
	Microsoft Corporation, $6-7 **
Materials	
	E.I. du Pont de Nemours and Company
Utilities	
	Ameren Corporation, $30
	American Electric Power Company, Inc.
	CMS Energy Corporation
	Duke Energy Corporation
	Entergy Corporation
	Integrys Energy Group
	PG&E Corporation
	Xcel Energy Inc., $20

Figure 31 - Internal Corporate Carbon Prices
Source: CDP, "Use of internal carbon price by companies as incentive and strategic planning tool"
Where no price is stated, a carbon price is used but is confidential.

Possible New Climate Regulation in next 1-10yrs

1. Renewable energy requirements and economic recession have depressed demand for EU ETS carbon permits and collapsed prices to trivial levels. As a result the EU or member states may follow the lead of the UK in imposing carbon permit price-floors or propping up prices artificially, as per the currently proposed 'market stability reserve'.

2. The US, Canada, and China have just begun limited ETS experiments and may expand the sectoral and/or geographic scope covered. India may adopt ETS trials for CO2 as well (currently has pilot ETS for particulates).

3. Countries like China or India may choose to adopt a Carbon Tax in lieu of, or in conjunction with a Cap & Trade system like the ETS. However, Cap & Trade tends to be more politically feasible because it possesses greater potential for market manipulation through permit allocation.

4. Renewable subsidies will be curtailed in Germany, Spain, and elsewhere fiscal budgets are under pressure and policy prohibitively expensive. Policies changes may be retroactive.

5. The UK has recently proposed a moratorium on new coal power station construction, and other EU members struggling with their energy mix (such as Germany and Spain) may soon follow or even restrict coal-powered energy production altogether.

6. As costs of meeting progressively increasing emissions targets accelerate, governments may turn/return to a nuclear solution.

7. World stock markets will be pressured into mandating carbon-reporting of traded assets. This change will likely occur within 5-10 years.

8. Climate polluters may face additional legal challenges to build new plants and litigation for damages from concerned organisations.

9. Given the chaotic nature of the climatic system, 'shock policies' (policies which have no precedent and/or a disproportionate economic impact) are a possibility in response to an exceptional climatic event. Although the probability of such a policy is low, their potential should be taken into account.

Implications

1. Given the primacy of regulation in climate change risk to RBS, the majority of mitigation efforts should be focused on conforming with and mitigating the effects of current and potential future policy.

2. Where climate regulations are deemed to be ineffective, insufficient, or even counterproductive, there is the greatest potential for regulatory change.

3. Policies aimed at reducing carbon emissions will impact the bills faced by industrial consumers. This will have the greatest effect on those industries that use the most electricity or release the most carbon in the production process including energy, steel/metal, chemicals, cement, food and paper. Over the past 10 years energy prices have roughly doubled in the UK. Similar increases can be expected in countries which adopt direct carbon-mitigation measures.

4. Renewable energy investments are subject to governmental caprice. Opposition government and popular support, strong fiscal positions, and modest subsidy levels are keys for expected long-term subsidy-price stability. Therefore renewable investment decisions must be stress-tested against the possibility of reduced government support and competition from oversupply due to subsidies.

5. Trading restrictions may increase and free-trade deals may be harder to strike in climate-regulated countries in order to prevent industrial leakage and incentivise reciprocal climate controls.

6. Coal power generation may be increasingly limited by government action, leading to asset write-downs and operating losses in coal power generation and upstream industries. Gas-fired plants to benefit.

7. Nuclear plant investment and uranium mining may return to favour, as is currently happening in Japan.

8. Corporations should be proactive in mitigating carbon footprints in anticipation of higher adjustment costs to future regulation. This means issuing an internal carbon price and setting up strategies to deal with regulatory and public relations contingencies.

3.3 Specific Banking Regulation

Banking regulation will be affected by climate-related environmental shocks. Whether this will result in the adoption of additional regulation- such as higher capital requirements is not yet resolved.

Basel III

At the heart of the discussion of banking regulation is the internationally accepted regulatory requirements as specified by the Bank for International Settlements. The recently introduced new capital requirements standards, Basel III, specify the capital requirements that banks have to fulfill to ensure a stable financial system. In this framework, BIS focuses on new minimum capital and liquidity requirements for banks.

In particular, Basel III calls for higher liquidity and capital ratios in order to; "improve the banking sector's ability to absorb shocks arising from financial and economic stress, whatever the source; improve risk management and governance; and strengthen banks' transparency and disclosures". [1]

A closer look at the Basel III regulatory framework, however, reveals that the recommended banking regulations do not explicitly include climate change as a potential source of systemic risk which could affect the entire financial market, and the banking system in particular. In our view, banking regulation thus far concentrates on reform and measures which should prevent bank failures due to external shocks, excessive risk taking within banks, or internal governance failures. Therefore, the BIS calls for tighter capital requirements in order to prepare banks for these kinds of shocks and to hold them accountable for the actions they take.

Looking ahead: Basel IV?

Clearly, the banking environment is and will be exposed to greater regulation. This is also illustrated by the following graph, published by KPMG in early 2014. Noteworthy is the fact that banks in Asia are substantially less exposed to regulation than banks in North America or Europe. This has also important implications for the future evolution of new banking regulation frameworks which might incorporate climate change as an important risk factor.

[1] Accessed 28 March 2014 http://www.bis.org/bcbs/basel3.htm.

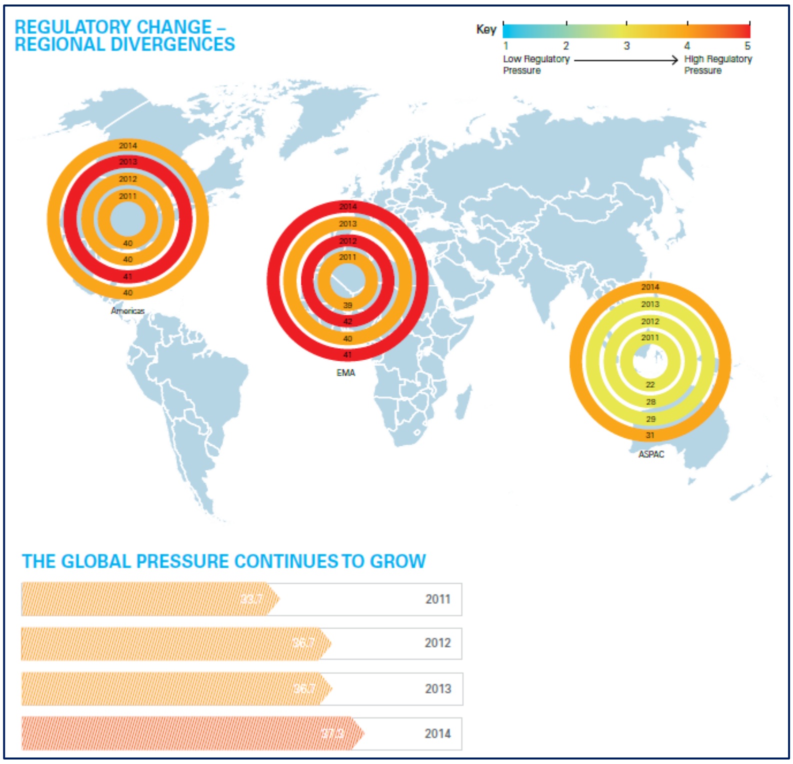


Figure 32 - Envisaged regulatory change for banks
Source: KPMG Report on Financial Services: "Evolving Banking Regulation - Is the end in sight?" (February 2014).

In general, several commentators envisage the emergence of the next Basel framework, namely Basel IV which could specify even stricter capital requirements and limits to the leverage ratio. According to KPMG, the 'next generation' of the Basel regulation will actually result in much "tougher requirements on the leverage ratio, risk-weighted assets and stress testing" (KPMG, 2014). Climate change especially affects the underlying asset base of banks, in particular when they lend to clients in climate- and environmentally-sensitive industries. This in turn affects the risk weighting of these assets, leading to higher capital requirements for such banks.

Whether climate change at one point will be explicitly taken up in the Basel framework or in any other regulatory framework is still an open question. However, we believe the explicit incorporation of climate change and environmental developments in these frameworks is justified, as climate change ultimately affects the lending portfolio, the asset base, and the sustainability of banks in the longer term.

Response of the financial industry?

To some extent, the banking industry will still regulate itself with respect to the future challenges that climate change imposes on it. This is so because, first, banks have started to incorporate climate change and other ESG factors in their credit assessment methodologies and, second, climate change also opens up new markets for banks. As the Stern Review on The Economics of Climate Changes argues, climate change provides many opportunities for players in the financial markets because they "have a vital role in raising and allocating the trillions of dollars needed to finance investment in low-carbon technology and the companies producing the new technologies" (Stern Review, p. 270). In a similar vein, Bowman (2013) argues that banks can be important facilitators in mitigating climate change. Banks should therefore not only view climate change as a potential risk for their business, but also as an opportunity for discovering new markets and product demand. Huge markets related to climate-friendly products, the financing of low-carbon technologies and companies, and climate-related insurance products, are already emerging.

4. Detailed Sector-by-Sector Analysis

Having investigated the general upcoming environmental challenges and climate related risks (physical and regulatory) for RBS and the financial market in section 3, we now turn to a discussion of environmental challenges within certain geographical regions and industrial sectors. Additionally, this section sketches implications for RBS's loan portfolio and other economic consequences relevant to RBS. First, this section looks at how climate change and temperature changes affect different geographies. Second, an evaluation of different industrial sectors is provided (commercial property, residential property, energy, transport, and agriculture).

Geographical perspective

Overall, the temperature change over the next 20 years will be dramatic. As the following graph by the IPCC illustrates (using a very plausible scenario), especially the northern hemisphere will be exposed to the highest temperature rise. It is also clear that changes will affect the winter of the northern hemisphere much more than the summer. The Northern polar cap will suffer the greatest increase of temperatures. This will have an impact on navigability as it is discussed later in the report. Other populated regions of the planet will suffer significant increases, as the UK (up to 1 degree) or North America and South Asia (up to 1.5 degrees). Such changes not only in the temperature, but also in the differences of temperature between poles and mid-latitudes, will have an impact on the probability of occurrence of extreme weather events, such as the recent cold snaps all over the U.S.A.'s West Coast and floods in the UK.

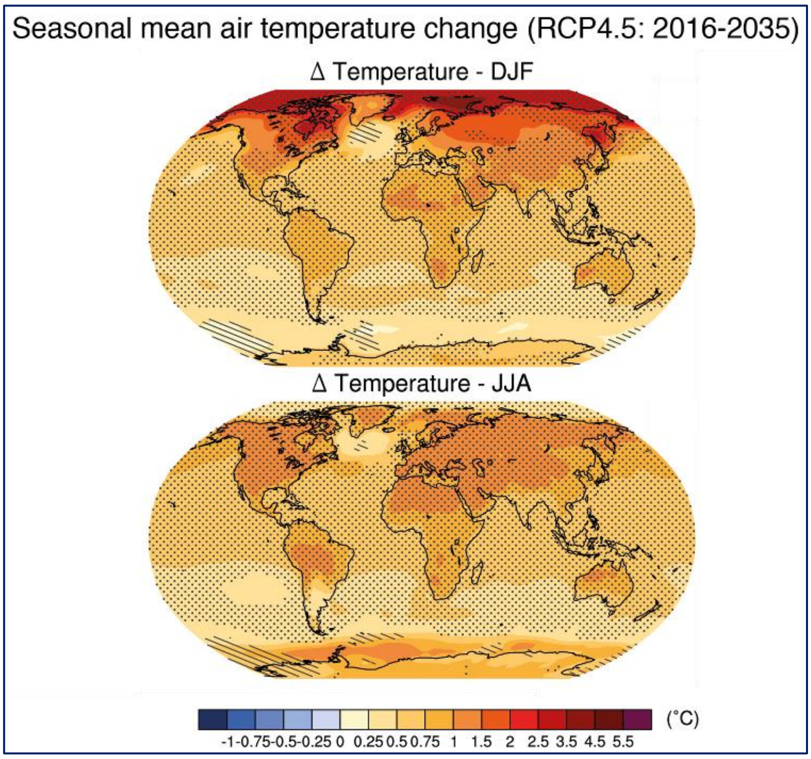


Figure 33 – Estimated air temperature change 2016-2035 for winter and summer seasons

Source: IPCC-WGI (2013)

Industrial sector exposure towards climate change and environmental challenges

Of course, different industrial sectors are exposed to different a degree of climate change and other environmental risks. To provide a first indicative overview of the different physical climate impacts and their relevant effects on corporate value chains, we present the following framework developed by Grossman et al. (2012). Their conceptual framework serves as the foundation for our discussion in this part of the report. One clearly sees that business sectors are exposed to different physical impacts. What is striking about this framework, and we also agree with this, is the fact that water scarcity is affecting almost every business sector - either directly or indirectly. Grossman et al. (2012) also point to the fact that extreme weather events such as floods and storms are the major source of risk for most business sectors. It is important to point out, that especially multinational corporations which have multiple production facilities in many different geographical regions are of course exposed to multiple risks and impacts on their value chain.

BUSINESS SECTOR	RELEVANT SHORT- AND LONG-TERM PHYSICAL CLIMATE IMPACTS	ILLUSTRATIVE EFFECTS ON VALUE CHAIN
AGRICULTURE, FOOD, AND BEVERAGE	• Water scarcity and droughts • Increased frequency and severity of floods and storms • Changing rainfall patterns and increased rainfall intensity • Increased weather extremes and variability • Rising average temperatures • Shifts in seasons • Rising sea level and increased saline intrusion • Changes in pest and disease distribution and prevalence • Loss of biodiversity	• Decreased crop yield and potential crop failures • Loss of productive land (e.g., due to increased soil salinity) • Altered growing conditions and seasons • Increased exposure to pests and diseases • Increased irrigation demand and costs • Commodity price volatility • Distribution network problems • Disruptions to farmers and labor force • Water conflicts with communities and other users (and damaged corporate reputation)
APPAREL	• Water scarcity and droughts • Increased frequency and severity of floods and storms • Changing rainfall patterns and increased rainfall intensity • Increased weather extremes and variability • Rising average temperatures • Rising sea level • Changes in pest and disease distribution and prevalence	• Fluctuating availability, quality, and cost of agricultural raw materials • Disruptions for operations and workers at manufacturing facilities • Disruptions in supply chain and distribution network, including transport, warehouses, and stores • Shifting consumer preferences (e.g., less reliable seasonal cycles and temperatures)

ELECTRIC POWER	• Increased intensity and duration of extreme weather events, such as heat waves, storms, and floods • Warmer average temperatures • Storm surge • Rising sea level • Water scarcity and overall variability in water supply and precipitation patterns	• Reduced output (e.g., inadequate quantity and quality of water for hydroelectric plants or to cool nuclear and fossil fuel plants) • Damage to infrastructure and facilities • Changing seasonal power demand and increased peak demand during extreme heat or other conditions • Increased electricity losses in transmission and distribution systems due to heat load
INSURANCE	• Virtually all physical effects, including hurricanes and storms, wildfires, floods, droughts, sea-level rise, thawing permafrost, and increased exposure to diseases	• Increased claims, losses, and liabilities • More difficulty pricing physical perils • Reduced availability and affordability of some types of insurance • Potential need for new products to address physical climate risks • Reduced value of investment portfolio
MINING	• Water scarcity and drought • Precipitation extremes and flooding • Increased intensity and duration of extreme weather events, such as storms • Rising sea level • Rising temperatures • Thawing permafrost and land ice • Increased wildfires • Increased exposure to diseases	• Constrained exploration, processing, refining, and site rehabilitation • Damage to infrastructure and facilities • Higher decommissioning costs • Altered access to mining deposits and coastal facilities • Disrupted transportation routes and reduced port availability • Risks to worker health and safety • Water conflicts with communities (and damaged corporate reputation)
OIL AND GAS	• Increased intensity and duration of extreme weather events, such as storms and floods • Rising sea level, higher storm surges, and increased coastal erosion • Land and sea ice melting and permafrost thawing • Water scarcity and droughts	• Damage to infrastructure and facilities • Rising risks to employee safety and health • Altered access to fossil fuel reserves • Constrained production of water-intensive oil and gas resources, such as oil sands, and water conflicts with communities and other users (and damaged corporate reputation) • Disruption of transport and distribution systems

Figure 34- Impacts of climate change on different business sectors
Source: Grossman et al. (2012).

In the following section, we discuss five major business sectors (commercial property, residential property, energy, transport, and agriculture) and the relevant climate impacts and consequences for RBS.

4.1 Commercial Property

Increased levels of direct physical damage are expected to occur to real property in the next 1-10 years as a result of global climate change. These effects will vary in form and intensity by location.

Climatic Risks to Real Property

	Effect	Vulnerable locations	Specifics
High Winds	Structure damage -Dependent on materials and construction Power outages	Dependent on topography Historic paths of hurricanes/tornados Coasts exposed to wave damage Roofs suffer most destruction	Land features magnify and dampen risk
Flooding	Structure damage -Dependent on materials Land Damage -Landslides -Sinkholes -Heave Water contamination -disease -sedimentation Rising damp Power outages	Coastal (result of high winds and tides) Near watersheds Low-lying History of flooding	Seawater more destructive than freshwater (ruins metal, arable land) Poor sanitation in developing countries magnifies risk of disease Dam, port dredging Water filtering costs
Drought	Groundwater depletion/soil drying land subsidence Wild fire damage Water rationing/disruption	Areas with heavy irrigation Areas with heavy vegetation cover Clay soils	Commercial water rights junior to domestic and agricultural users
Cold Snaps	Expanding ice damage -infrastructure -burst water pipes Structural cracks	Mid and high latitudes	
Heat-waves	Little to no damage		

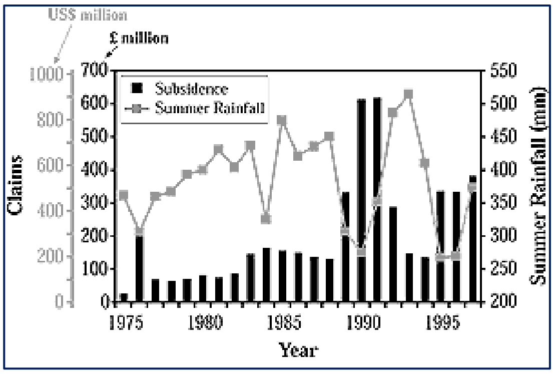


Figure 35 - Summer rainfall and subsidence claims in the UK: 1975-1997.
Source: IPCC (2001). Rainfall data are for England and Wales, April to September (from Climatic Research Unit, University of East Anglia, UK). Subsidence claim costs are in original-year values (from Association of British Insurers).

The more frequent incidence of climate-related events is set to cause buildings to depreciate more rapidly and to incur greater maintenance and insurance costs. Furthermore rising insurance costs may not be limited to vulnerable areas as governments may force land-owners in relatively safe areas to subsidise risky premiums; as the UK government has done with their universal Flood Re insurance surcharge beginning 2015.

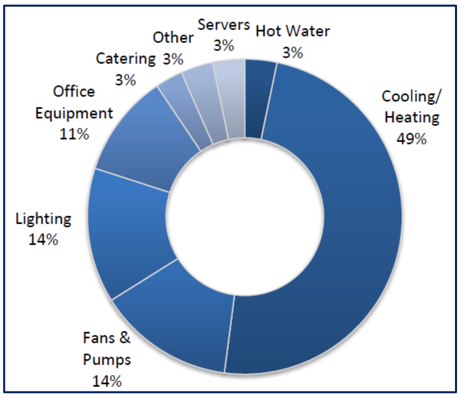


Figure 36 - Typical office energy use
Source: International Finance Corporation, World Bank Group,' IFC Green Buildings'

In addition to physical damage, climate change and legislation aimed at its mitigation will likely also increase building operating costs for energy and water and the security of their supply. Energy is the single largest building operating expense, representing 20-30% of operating costs in a typical office building, and up to 80% of total lifecycle costs, with lighting and heating/cooling taking up 60-80% of energy demand depending on climate. In the UK, lowest versus highest quartile typical office and shopping centres have running cost differentials of 50%.

With retail energy prices doubling in the past decade in the UK, and further increases in the EU forecast as a consequence of energy-related climate regulation, increasing running costs is a significant risk. Blackouts may also become more frequent as EU countries tinker with higher a renewable (and lower base-load) energy mix.

Figure 37 - UK cost of utilities
Source: Castle Cover Insurance

Typically water represents only 3-4% of total operating costs and is therefore of second order importance compared to energy. But because water is not currently rationed by prices alone, in the event of devastating drought there is potential for supply interruption to commercial property as governments ration water based on political expediency, with residential and agricultural users generally given more senior water rights.

Existing buildings can mitigate these physical climate and regulatory risks by undergoing structural alterations to prepare for damage and by replacing energy and water-inefficient systems. The costs associated with mitigating physical and regulatory risk may lead to less competitive rental rates and higher vacancy rates until prices adjust. However, current research suggests that energy efficiency is at least fully-capitalised and often extra-capitalised in both property prices and rental values; suggesting that in addition to standard savings on running costs, mitigating regulatory risk is a form of value-add to tenants (Eichholtz, Kok, and Quigley, 2010; Eichholtz, Kok, and Quigley, 2013; and Reichardt et al, 2014).

Development

The cost of building construction in the UK has increased 50% in real terms since the 1990s. Beginning in the mid-2000s the rate of increase in the price of construction materials has outstripped the rate of increase in the price of labour and physical capital. These trends can be expected to continue, with key components of building construction such as concrete and steel especially penalised by regulation for their high carbon footprints. New commercial properties are also being required by governments to build to higher environmental standards, not only increasing construction costs but also permitting delays. Climate events may also hinder the timely progression of building construction, magnifying development risk. These costs rises will impact supply growth, causing rents and property values to rise.

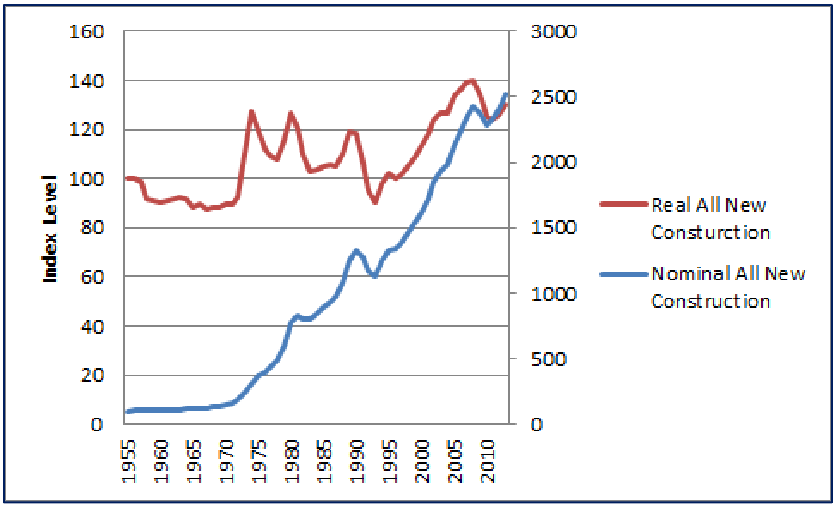


Figure 38 - BIS UK Construction Output Price Index of All Construction
Data source: 'Real All New Construction' is 'Nominal All New Construction' scaled using ONS National Accounts GDP deflator. Own graphic.

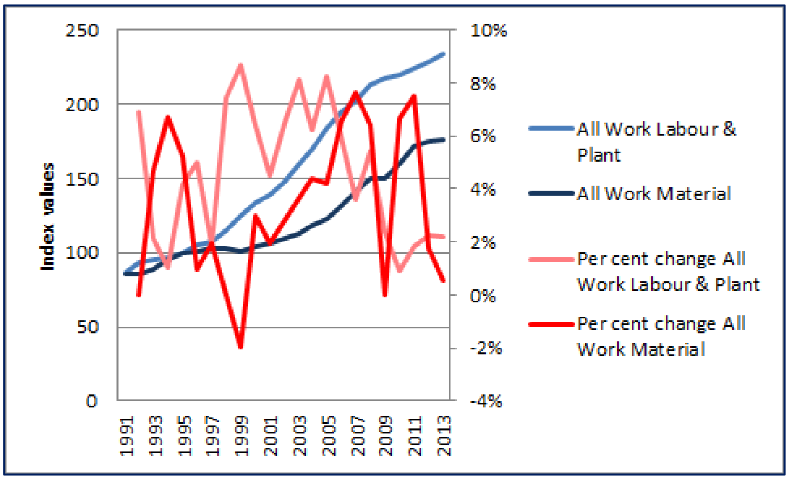


Figure 39 - BIS UK Resource Cost Index of All Construction
Data source: 'All Work Labour & Plant' Refers to constructions costs for both new buildings and refurbishments for Labour and Physical capital. 'All Work Material' Refers to construction materials costs for both new builds and refurbishments. Own graphic.

Implications

1. Property owners must assess and address their local vulnerability to increasing climate risks through physical preparations and insurance.

2. Larger contingency funds should be held in anticipation of disruption to property operations and development, as even insured losses takes time to be reimbursed.

3. There is much potential for profitably retrofitting buildings in the UK for increased energy efficiency, and these savings can increase property values by even more than the value of the nominal cost-savings.

4. Property development costs will continue to rise due to increased regulation and cost of materials. As a result, development delays will amplify costs and new supply will be constrained causing the price of space to rise, ceteris paribus.

4.2 Residential Property

Homeowners will also be subject to the same physical climate, regulatory, and utilities cost risks that commercial properties face. However homeowners are likely to be better shielded by their governments from serious consequences of these. From the insurer's perspective, residential properties are also smaller, more widespread geographically, and less likely to earn an income; reducing the variability of impairment claims made in the event of natural disaster.

UK 2013-14 Floods

The academic evidence on flooding incidents with respect to housing markets finds the following general results in the UK, US, and Australia across multiple time periods and geographies[2].

1. Flooding has only a temporary impact on property values. After 3-9 years, but more commonly 3-4 years, prices return to their normal market-level relative to properties which did not flood.

2. Flood events in low risk areas have no impact on property prices.

3. Being designated at high risk of flooding has no effect on property values in areas with no flood events.

4. Insurance remains available to householders in the UK, with flood risk not being the major factor in determining levels of premiums.

5. At point of purchase, there is not a high level of awareness among homeowners of the flood risk to their property, and this is particularly true among longer-term homeowners.

4.2.1 RBS Mortgage Research Questions

RBS has recently enacted a payment holiday for their borrowers affected by the recent floods. When should payment holidays be enacted?

By enacting a policy of payment holidays for borrowers affected by environmental disaster, RBS is reflecting a degree of implicit exposure to these risks. Even so, such a policy could make sense from both a public relations and a portfolio management perspective. In the medium-term enacting payment holidays in the event of environmental disaster may increase profitability by improving customer loyalty and their desire to meet future repayments in the face of personal hardship. Payment holidays could also be used as a platform for advertising; attracting new customers and cultivating a positive social image – especially where government assistance and charity is seen as inadequate or where the loss was completely unexpected. Moreover, when other banks also offer financial assistance, any failure to respond in kind would have negative reputational and perhaps political consequences. Given both the profit motive and reputational incentives for offering financial concessions, we

[2] Source: RICS (2009), Atreya et al. (2013), Speyrer and Ragas (1991), Lamond et al. (2013), Lambey and Cordery (1997)

believe that the relevant metrics for deciding when to offer these concessions should be based on both what is happening to RBS's loan book and the response of other actors to the event in question.

Cues to offer special financial concessions - in order of relative severity

Internal cues	External cues
A 'significant fraction'† of borrowers affected by the event request forbearance. A 'significant fraction'† of loans whose borrowers were affected by the event become delinquent	Media/political criticism of aid response/preparation Major competitors extend assistance General charities solicit donations for the specific event Government offers special assistance; such as extending tax deadlines, deploying the military, distributing basic essentials Government declares a state of emergency as a result of a climatic event (rarely invoked in UK)

† Historical data on changes to these variables during events later deemed 'significant' can be used to construct appropriate thresholds.

As there is positive publicity in being the first to offer assistance, once any of the above aid cues are anticipated with high probability, RBS should announce an assistance plan to the media. In order to be able do so, RBS should have a protocol of policy responses it can draw upon depending on the disaster in question, its severity, and RBS's capability to provide assistance. In addition, this announcement should make clear any FAQs posed by both the media and the public - as RBS does not want to be in HSBC's position during the last floods of having the media report an 'unclear' policy of whether mutually agreed payment holidays will count against a borrower's credit file, for instance.

UK Bank Payment Holiday Response to 2013-14 Flooding

	Payment Holiday	Emergency Loans	Special Employments	Credit file Impact on Borrower
RBS **NatWest**	Mortgages 3 months max	£250m UK Storm Business Fund Overdrafts and limits extended ATM withdrawal limits increased	Loss-adjusters for businesses posted to worst-hit areas Home insurance customers offered accommodation	None
HSBC **First Direct** **M&S Bank**	Loans & Mortgages 3 months max Possibly reduced loan fees	Limits on emergency payments removed for insurance customers Fast-track credit evaluation Lending limits based on needs rather than caps Overdraft fees may be waived	Loss-adjusters posted to worst-hit areas Extra staff at call centres Contacting residential & agricultural customers	Unclear
Santander	Mortgages on case-by-case basis Business loans 6 months max - additional support possible Farmers 12 months max	£100k impacted communities fund Overdraft fees for business or personal waived	None	None
Barclays	Residential & Business mortgage customers 6 months max Loans 6 months max Farmers 12 months max	Loans available for insurance customers Temporary overdraft increases	None	None
Bank of Scotland **Halifax** **Lloyds** **TSB**	Unclear if payment holidays available for personal users Payment holidays for business Mortgage holidays on case-by-case basis	Overdraft allowed for farmers Businesses can increase overdraft limits Same-day transfers available to personal banking customers	Loss-adjusters posted to worst-hit areas	None for business customers
Nationwide	Unclear - number to call if in hardship	Temporary overdrafts and increases to present limits	None	None
AXA	None	£1000 Emergency loans made to affected customers	Proactively contacted and advised customers at risk Customers offered free accommodation	N/A

However, a payment holiday policy also creates the expectation that RBS is to perform functions previously borne by a combination of the insurance industry, charity, and government. As with most forms of insurance, the potential for moral hazard in the face of environmental disasters could arise if borrowers were to invest in areas more prone to damage *because* of RBS's payment holiday policy. On balance however, other factors such as mandatory risk-sharing via Flood Re would appear to override RBS's marginal incentive, and therefore we believe this risk to be negligible.

Implications

Develop a mortgage holiday protocol based on public relations and total repayment advantages.
Make sure that measures can be communicated clearly to customers and the media.

1. Develop a mortgage holiday protocol based on public relations and total repayment advantages.

2. Make sure that special financial assistance can be communicated clearly to customers and the media.

3. Equity loss is not always associated with a flood event.

4. Equity-loss or negative-equity arising due to flooding is temporary and will only affect homeowners in the near-term. Therefore temporary assistance schemes are adequate.

5. As homeowners are often caught unawares about flood risk to their property. There may be potential for RBS to inform existing mortgage holders and new applicants to improve flood mitigation.

4.3 Energy

Counter to claims that the world is close to running out of fossil fuels, there are currently enough known reserves to exceed the 2°C carbon allowance by at least three times, and likely many times this awaiting discovery. The economics for fossil use is still strong, with significant reliance on the three major fossil fuels expected through at least 2040. However, a combination of regulatory, public opinion, technological and environmental changes will create new challenges and opportunities for this industry in the coming decade.

Climatic Risks to Energy

	Effect	Vulnerable locations	Specifics
High Winds	Physical damage/loss Oil-spills in sea storms Wind power unoperational Storm damage to transmission lines	Historic paths of storms	Exposure to wind damage affected by situation and design of infrastructure
Low Winds	Wind power loss		
Flooding	Power loss Hydro-power loss Mines inundated	History of flooding	Electrical shorts Overtopping Sedimentation and debris damage
Drought	Power plant shutdown Hydro-power loss Nuclear power plant shutdown Fracking costs	Low-rainfall regions	Loss of water coolant Loss of water generation Lack of water coolant Lack of water to frack
Cold Snaps	High energy demand	Mid and high latitudes Landlocked areas	Equipment failure
Heat-waves	Ice cover / permafrost opens for oil exploration Nuclear and fossil fuel power plant shutdown High energy demand Decreased transmission capacity of electricity	Global effects	Fossil fuel reserves increase Overheating of landlocked power plants Jellyfish fouling of coastal power plants

Downstream

Storms will affect the depreciation of physical infrastructure and maintenance costs in the energy industry in much the same way as commercial property. However, the potential for local and environmental damage in the energy industry is greater because energy infrastructure combines heavy machinery with volatile compounds in areas highly exposed to the elements. BP's Deepwater Horizon oil spill of 2010 showcases the possible extent of such damages.

On the production side, the energy-water nexus and impacts from climate change are clear. Water is critical for hydropower, thermoelectric generation and cooling of power plants, fuel extraction and refining and fuel production. Indeed over 90% of global electricity generation requires water. In 2012 and 2013 alone the US, China, India, and Brazil have had to slash hydropower and thermal generation due to persistent droughts causing blackouts. During the 2006 European heat-wave, France and Germany were forced to reduce nuclear production because of water coolant overheating. These trends are expected to increase. According to van Vliet et al. (2012) "Europe's coal and nuclear power generating capacity will fall 6% to 19% between 2031-2060 due to increased water temperature or lack of cooling water ", and "nearly 93% of Middle East's onshore oil reserves are exposed to medium to extremely high water risk ".

Upstream

Oil & Natural Gas

Oil is the most expensive fossil fuel and is used primarily for transport. The most carbon-intensive oil reserves are from tar sands. Therefore, like coal, these reserves may face regulations in the coming years to tax or ban its extraction. Natural gas on the other hand, is the least carbon-intensive fossil fuel for a given unit of energy. Given that natural gas is relatively 'clean', it is likely to be favoured by regulation when guaranteed base-load is required, as is already the case with the UK's 'Capacity Market' whose auctions commence this year.

On the whole, operational costs are rising for the oil and gas sector as discovering and exploiting new reserves becomes more difficult and exposure to unconventional technology increases. However in recent years the market for natural gas has seen a sea change in the US due to horizontal drilling and hydraulic fracturing (aka 'fracking') - which although water-intensive allows for the extraction of previously unprofitable hydrocarbon reserves.

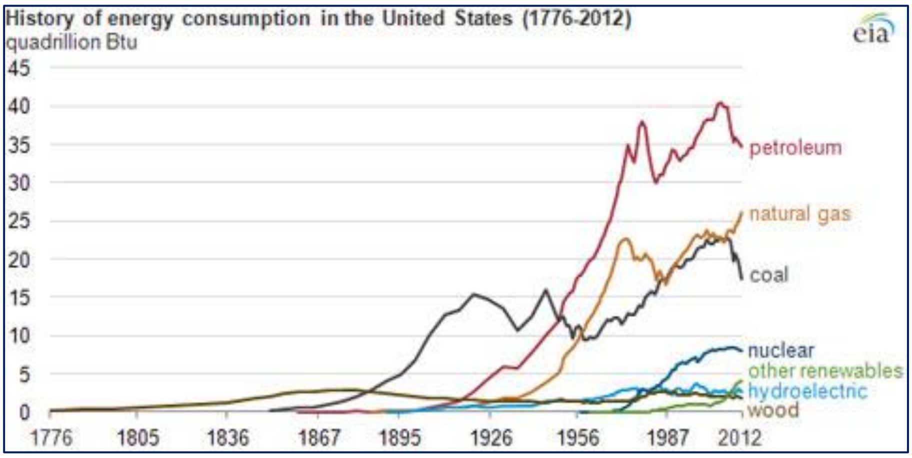


Figure 40 – History of Energy Consumption in the United States
Source: US Energy Information Administration

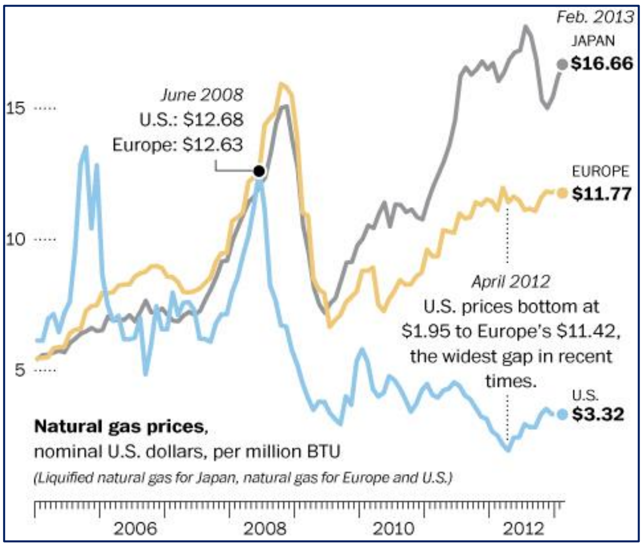


Figure 41 – International Natural Gas Price Differentials
Source: World Bank Commodity Markets, The Washington Post. Published April 1, 2013.

Low natural gas prices in the US as a result of fracking have revolutionised the US energy industry, with coal use falling considerably. For many other markets around the world the rise of shale gas and a concomitant fall in natural gas prices have the potential to transform fossil fuel power generation, with substitution away from coal and increased energy independence the result. However, these changes will not be crucial outside the US until after the next decade due to regulatory barriers for extraction and export bans in the US. In spite of recent controversy in the EU, as the cleanest fossil fuel, 'fracked' natural gas represents an important bridge to the low-carbon economy.

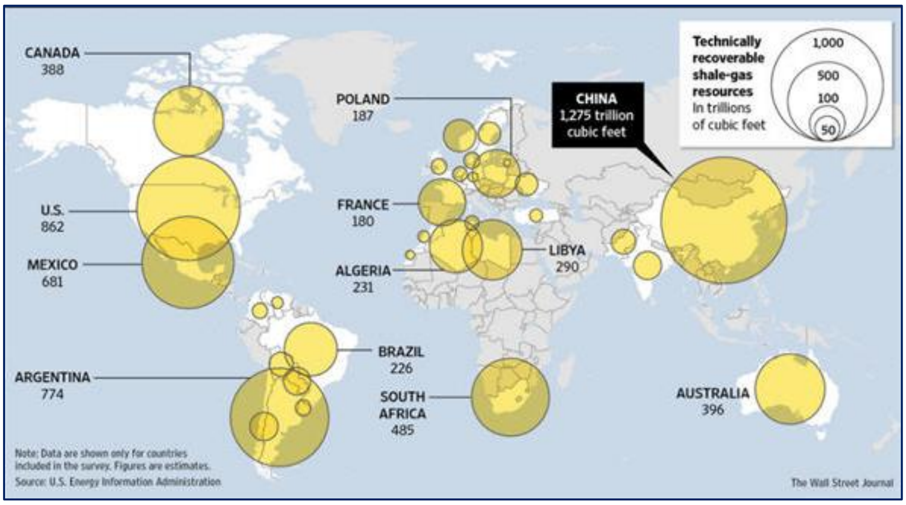


Figure 42 - Global Shale Gas Deposits
Source: 'Global gas push stalls' The Wall Street Journal Dec.3 2012.

Figure 43: EU Shale Gas Deposits
Source: International Energy Agency

Arctic oil and natural gas reserves are estimated to be between 13-30% of undiscovered world reserves (90 billion barrels). Exploration of these reserves continues to be extremely expensive. However climate change and increasing fossil fuel prices are making arctic reserves more affordable, although such supplies are not expected to have an impact on the market before 2030-2050.

Coal

Because coal can be readily transported but natural gas cannot, the shale gas boom in the US has led to an influx of US coal into the EU, a drop in prices, and fuel switching. It is a perverse regulatory outcome that coal is now the most profitable fossil fuel to generate electricity, with cleaner gas-fired plants largely seeing negative 'spark spreads'. Given these misaligned financial incentives, coal is likely to be targeted by regulatory constraints in the EU, with bans already proposed in the UK. Were the EU to adopt such a policy, the lead market may be a useful analogy: falling 44% after the ban of leaded petrol due to health concerns. As the dirtiest fossil fuel, coal may experience similar price declines in large markets as a result of such regulation. However, since 89% of the world's coal assets are owned by governments, and because coal unions often politically powerful, we can expect that the willingness of governments to sacrifice these assets will be patchy, and that in the majority of jurisdictions coal will continue to be readily and cheaply available.

Aside from the threat of an outright ban on coal by governments, coal assets may prove financially damaging indirectly due to the reputational risk of extending loans to coal industries. Public backlash may drive customers away from RBS and invite greater regulatory scrutiny from the regulators in other affairs.

Nuclear

A major impact of climate change on the nuclear power industry arises from extreme heat-waves and droughts. These phenomena affect the temperature and availability of the water used for refrigeration. If water is too hot or in short supply, unexpected shutdowns and power outages may be necessary. In recent years jellyfish fouling of intake pipes has also emerged as an intermittent climate-related problem for nuclear power stations located on coasts in mid-latitudes.

Nuclear is the only widely deployable carbon-free base-load power generation technology. Of course it also has mortal risks, but as governments confront the high cost and low-base-load drawbacks of renewable energy they may (re)turn to a nuclear solution. In the next ten years such changes of heart are possible. For instance, Japan has recently expressed the intention to restart its nuclear fleet after balking at the enormous current account deficits arising from fossil fuel import switching. Of course, it would only take another nuclear disaster to send the industry into public disfavor again however. Newly commissioned plants on the other hand will not affect energy supply or demand in the next 10 years, as regulatory approval and construction timelines are beyond this range.

Renewable energy

Due to government subsidy and rapidly falling manufacturing prices, renewable energy (hydropower, wind and solar power) represent a growing fraction of the energy mix in many countries, but especially the EU. In Germany and Spain, competition with renewables has had a direct impact on the profitability of coal and gas-fired plants. Zero marginal costs of production mean that, once built, renewable energy plants can profitably out-bid any conventional generation technology. However much renewable energy suffers from a lack of base-load capacity, and until large scale energy storage and transport via interconnected grids becomes possible, fossil fuel generation will remain necessary. Moreover, the ability of renewable generators to store energy will become more important as climate variations increase.

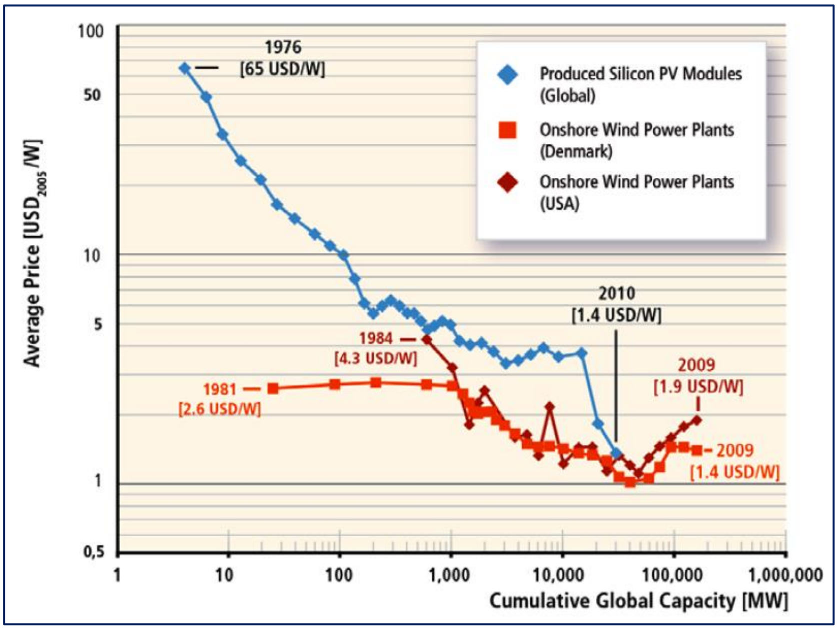


Figure 44 - Renewable energy price declines
Source: IPCC Special Report, Renewable Energy Sources and Climate Change Mitigation

Hydropower production is expected to be affected by regional rainfall variations arising from climate change. For southern Europe the potential hydropower production by 2070 is expected to decrease by a 25% and a 6% for the whole continent. By 2020 a substantial decrease in local river discharge (and therefore water available for hydropower production) is also expected in some regions, while others may increase. Over the next 20 years this worldwide variation is a net wash, however, as the fraction of global energy generated from hydropower is expected to remain relatively constant.

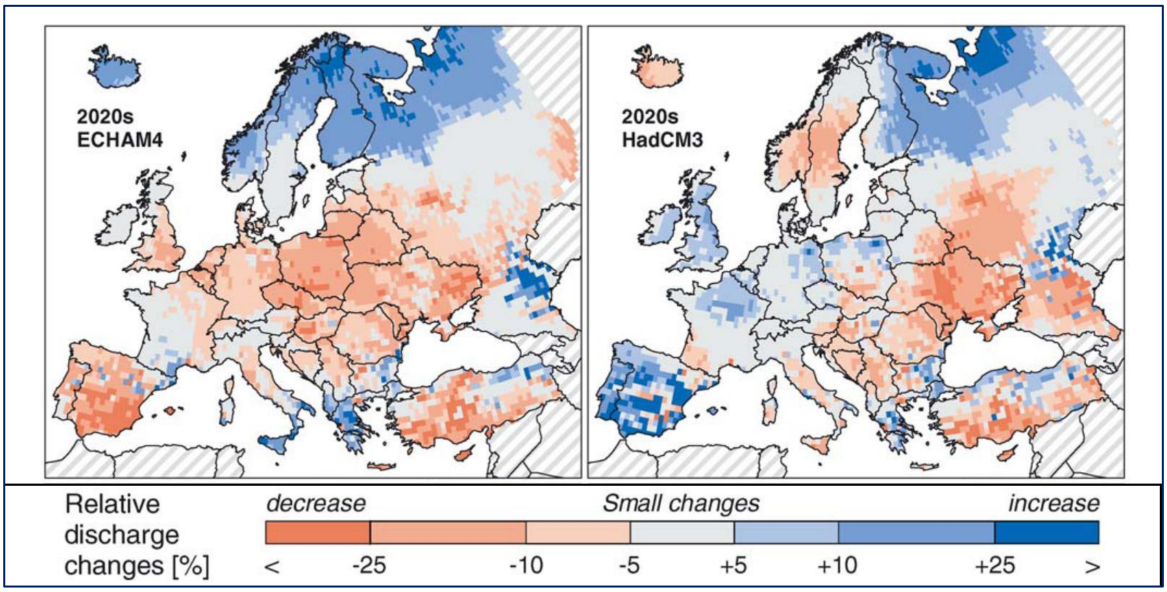


Figure 45 - Relative changes of average (1961–90) discharge volumes as calculated by the model WaterGAP. "The maps show realizations for the 2020s based on outputs of the ECHAM4 and HadCM3 climate models, and the Baseline-A water use scenario (represent a set of 'business-as-usual' assumptions about population growth, economic growth and economic activity, and imply an average annual increase of carbon dioxide emissions of 1% per year.). The values are visualized at the cell level of WaterGAP's calculation grid at 0.5 resolution." (Lehner et al., 2005). Source: Lehner et al. (2005)

Hydropower generation by region		2008			2035			CAAGR 2008–2035 (%)
		TWh/yr	EJ/yr	% of global electricity supply	TWh/yr	EJ/yr	% of global electricity supply	
World		3,208	11.58	16	5,533	19.97	16	2.0
OECD	OECD total	1,312	4.74	12	1,576	5.69	12	0.7
	North America	678	2.45	13	771	2.78	12	0.5
	USA	257	0.93	6	310	1.12	6	0.7
	OECD Europe	521	1.88	14	653	2.36	15	0.8
	EU	327	1.18	10	402	1.45	10	0.8
	OECD Pacific	114	0.41	6	152	0.55	7	1.1
Non-OECD	Non-OECD Total	1,895	6.84	20	3,958	14.29	18	2.8
	Eastern Europe/Eurasia	284	1.03	17	409	1.48	17	1.4
	Russia	165	0.60	16	251	0.91	18	1.6
	Non-OECD Asia Total	834	3.01	16	2,168	7.83	14	3.6
	China	585	2.11	17	1,348	4.87	14	3.1
	India	114	0.41	14	408	1.47	13	4.8
	Africa	95	0.34	15	274	0.99	23	4.0
	Latin America Total	673	2.43	63	1,054	3.81	59	1.7
	Brazil	370	1.34	80	528	1.91	64	1.3

Note: 1. The 'new policy scenario' reflects conditions set forth by the UNFCCC's Copenhagen accord, and is considered a reference scenario by the IEA.

Figure 46 – Expected changes in hydropower generation by region
Source: IPCC (2012b)

For wind power there are two major threats derived from climate change: extreme wind speeds and changing weather patterns. Extremely high or low wind speeds will become more usual under climate change conditions. Under both these conditions wind power generation is not possible. However, under high winds damage to wind turbines is also a risk. Therefore, higher maintenance costs can be expected, and lower electricity contributions per turbine are possible going forward. In addition to increased wind variability, changes to weather patterns as a result of global warming can alter distribution of wind fields, and therefore affect wind-farm profitability.

Solar power will not be strongly affected by climate change. Although changes to cloud cover rates have the potential to influence solar generation, these effects will be marginal.

Energy market structure

In order for renewables to be rolled-out across the European Union, the EU is pursuing the construction of new international grid capacity and connections. Although these improvements have been slow in coming due to national regulatory barriers and financial constraints, once they do come online these linkages will, to a considerable degree, unify the market for European electricity. The effect of this change will be to increase competition both between firms and between generation technologies. Such a common market would have the effect of making renewables technology more attractive for base-load generation, and would equalise interregional and even international electricity prices. The end result across the EU may look similar to the current situation in Germany, where many incumbent energy firms (RWE, Eon) have been put under extreme pressure by more efficient competitors (in this case renewables funded by government incentives).

Amidst this backdrop of increasing market integration in the EU generally, the competitiveness of the electricity market in the UK is currently being investigated by the CMA. The fallout of this inquiry could be a compulsory break-up of the big-6 energy firms in order to increase competition. This investigation has cast a spectre of uncertainty over the industry in the UK, and if the CMA indeed finds evidence for collusion it could open a Pandora’s box of potential corporate break-ups elsewhere in Europe.

Implications

1. The ‘dirtiest’ forms of fossil fuel generation will be increasingly challenged by regulation, subsidy from competing clean technologies, and public sentiment.

2. Climate change will increase the costs of fossil fuel energy production and extraction in water-scarce regions.

3. Shale gas exploitation is an important bridge to a low-carbon economy and will lead to coal switching in the medium-term.

4. Increasing renewable generation will make the proportion of fossil sources less important for electricity production, but fossil fuel’s primacy is expected until at least 2040.

5. EU mandated energy market integration will increase competition among firms and between generation technologies, with renewables to benefit the most.

4.4 Transport

In the next 10 years the most important impacts of climate change on transport will be due to disruptions and damage from extreme weather events.

Climatic Risks to Transport

	Effect	Vulnerable locations	Specifics
High Winds	Disruptions to air transport and changes to the jet stream Increased harbour days and damage to ships Physical damage to infrastructure	Changes to air transport routes	Changes to revenue per kilometer flown (positive and negative)
Flooding	Impassable roads River navigability Physical damage (destruction of roads, bridges, weirs)	History of flooding High traffic rivers	
Drought	River navigability	High traffic rivers and canals	Increased shipping costs and relocation of economic activity
Cold Snaps	Dangerous icy roads Rail and road buckling Higher road maintenance costs Disruptions to air transport	Mid and high latitudes Landlocked areas	
Heat-waves	Rail and road buckling Disruption to rail and road transport because of wildfires Lower air density North West passage navigable (benefit)	Landlocked areas	Reduced shipping costs Increased fuel consumption due to reduction of engine efficiency and increased required runway length

Extreme weather event		Infrastructure Assets (m€)	Infrastructure Operations (m€)	Vehicle Assets (m€)	Vehicle Operations (m€)	User Time (m€)	Health & Life (m€)	Total (m€)
Storm	Road (1)	76,10	22,60	5,10	1,40	63,00	5,90	174,10
	Rail (2)	0,07		12,05		6,28		18,39
	Maritime (5)			2,10	17,98			20,08
	Intermodal (6) (7)	0,53					0,72	1,25
	Air (8)			53,80	34,30	38,40	28,30	154,80
Winter	Road (1)	248,80	126,30	81,30	12,50	125,50	164,90	759,30
	Rail (2) (3)	0,04		3,38		1,60		5,02
	Intermodal (6) (7)	0,21					0,21	0,42
	Air (8)		11,20	12,00	57,70	64,60	1,90	147,40
Flood	Road (1)	630,10	21,90	24,40	30,01	93,70	21,50	821,61
	IWW (4)					4,87		4,87
	Rail (2)	103,66		111,60		67,30		282,55
	Air (8)			3,20	26,50	29,60	0,20	59,50
	Intermodal (6) (7)	0,32					0,10	0,42
Heat&drought	Road (1)						46,90	46,90
Total		1059,82	182,00	308,92	180,39	494,84	270,63	2496,60

Figure 47 - Average extreme weather event costs (2000-2010) for the European transport system (annual data in million €).
Source: Enei et al. (2011).

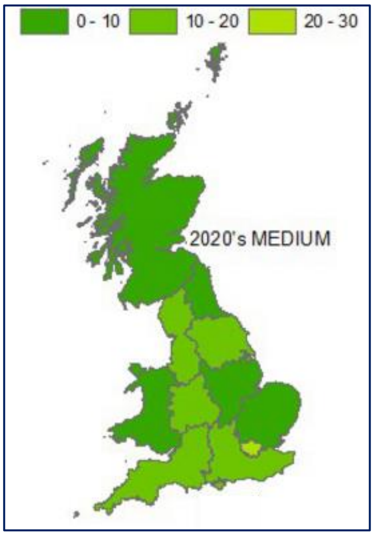


Figure 48 - Projections of the number of rail buckles (per country/region) by the 2020's with 90% level probability.
Source: DEFRA (2012b).

Area	Market size (in tonnes)	Economic effects	Method	Details
Rhine area: Kaub-related IWT trips	80 million (year 2003)	Between €81 and €146 million (year 2003)	Multiple regression analysis with time series aspect, microdata	Size economic loss varies with model specification
Total Rhine area + Moselle area	187 million (year 2003)	Between €194 and €263 million (year 2003)	Multiple regression analysis, microdata	Size economic loss varies with chosen route (intensity of transport price increase) for a bundle of trips
North West Europe	382 million (year 2003)	Between €410 and €479 million (year 2003)	Multiple regression analysis, microdata	Size economic loss varies with chosen route (intensity of transport price increase) for a bundle of trips
The Netherlands (domestic)	100 million (year 2003)	€111 million (year 2003)	Inland shipping network (simulation) model	Extra transport costs due to low water
Great Lakes (US)	180 million (mid-1980s)	$65 million (mid-1980s)	Combination of climate, hydrological and economic model	Extra transport costs due to low water
Great Lakes (US)	n.a.	$2 million	Simulation of 1989 pattern of shipments	Extra transport costs due to low water
Great Lakes—St. Lawrence River system (US)	70 million	$75 million	Simulation of year 2001 operating costs for commercial navigation	Extra transport costs due to low water
Middle Mississippi river (US)	120 million	$118 million	Monte Carlo simulation	Economic losses are defined as extra costs due to switching to more expensive modes
Oklahoma + 9 surrounding states	2 million	$465 million (value lost production) and $1.1 million (extra transport costs)	Input–output model	The study concerns economic losses due to a port closure of 1–2 months
Rhine, middle Germany	1 million	€50–€55 million (of which €22 million for alternative transport)	Results based on surveys among transport operators, interviews with stakeholders and inland navigation statistics	The study concerns a river closure of 33 days due to an accident with an inland vessel

Figure 49 - Selected cases of impacts from droughts on inland waterway transport.
Source: Jonkeren et al. (2013).

Our evidence regarding climate change and its implications for the transportation sector implies that there are not only obvious risks and challenges involved for banks, and other financial market participants. Clearly, the increased frequency of extreme weather events such as cold snaps, floods, and storms, exposes the infrastructure and the transportation sector to huge challenges and risks. Whereas these physical effects on corporations in the transportation sector imply a huge financial risk which may arise from physical damage and financial losses, financial market participants such as insurance companies and banks can also gain from this development in this business sector.

In particular, climate change opens up several new market opportunities for products which directly address climate change and its consequences arising from climate change. Huge infrastructure projects are going to be started in order to recover the damages from extreme weather events which may require the financing expertise of banks. As most infrastructure projects require project financing structures and in turn financial expertise, this also creates new demand for banking products and financial services.

Implications

1. Extreme weather events will lead to a destruction of infrastructure, especially roads, railways, and vehicles. This has direct consequences for transportation companies and infrastructure investments, and indirect effects for banks as creditors of these entities.

2. New opportunities for banks: The re-building and renovation of existing and damaged infrastructure needs huge investments and project financing structures: Increased demand for financial expertise in project finance and infrastructure development.

4.5 Agriculture

As climate is a crucial element of ecosystem function, it is no surprise that climate change has wide-ranging implications for agriculture. Given that agricultural products are also traded on commodity markets, we will also discuss the major implications of climate change for banks and investors actively participating in those markets.

Climatic Risks to Agriculture

	Effect	Vulnerable locations	Specifics
High Winds	Crop loss	Dependent on topography Regions affected by tropical cyclones	Leaves and crop stripped
Flooding	Crop failure Soil loss/contamination	History of flooding	Land no longer arable Crops drowned
Drought	Crop failure Dust bowl soil loss Groundwater depletion and land subsidence	Areas which lack or require irrigation Fine soils	Riots in developing world Land value loss
Cold Snaps	Crop failure Reduced growing seasons	Mid to High Latitudes	Frost damage
Heat-waves	Crop failure Longer growing seasons Crop switching (risk and opportunity)	Global effect Mid to High Latitudes	Some farmers continue growing at higher altitude British wine

As regions warm, crops will also need to migrate north or to higher altitudes. Moreover, earlier springs have meant that pollinator hibernation is now out of sync with crop blooms, increasing the cost of managed pollination. While some northern regions will benefit from longer growing seasons, many farmers will be forced to grow new crops they lack experience with - reducing harvests. Over the near and medium-term however, the most important climate-factor for agriculture is freshwater availability for irrigation. The projections of availability of freshwater for irrigation show a strongly negative trend for the coming decades (Haddeland et al. 2014). Drought effects can also linger after rains have returned. During the 1930s US dust bowl phenomenon, arable land lost 28% and 17% of its value in high and medium soil loss areas.

Projections for global crops output clearly show negative trends in all scenarios, and even with wider adoption of technology in the developing world, greater conversion of agricultural land will be required to feed the world's growing population. In a break from their 2007 report, where they were more sanguine about effects of climate change on harvests, the IPCC has come out strongly negative on food production, with wheat, maize, and rice yields particularly hard-hit. Food prices may have knock-on effects for political stability. The trigger for the 2011 'Arab Spring', for instance, has often been blamed on a precipitous rise in food prices that year following disastrous harvests in Russia, Ukraine, China, Argentina, Canada, Australia, and Brazil due to droughts and storms in 2010.

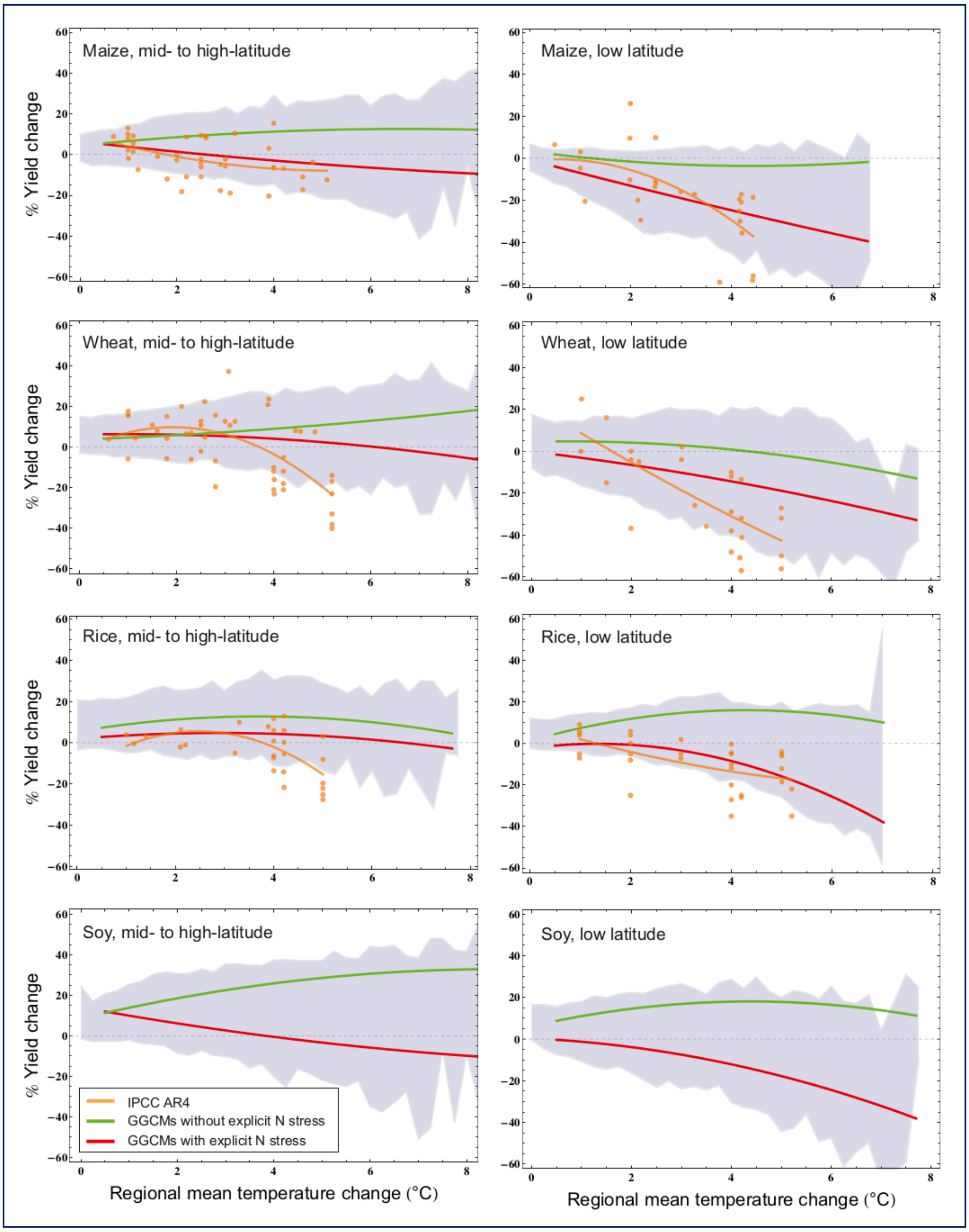


Figure 50 - Mean relative yield change (%) from reference period (1980–2010) compared to local mean temperature change (°C) in 20 top food-producing regions for each crop and latitudinal band.
Results shown for the 7 GGCMs (6 for rice) for all GCM combinations of RCP8.5 compared to results from IPCC AR4 (represented as orange dots and quadratic fit; 36). Quadratic least- squares fits are used to estimate the general response for the GGCMs with explicit nitrogen stress (red line) and for those without (green line). The 15– 85% range of all models for each 1⁄4°C band is represented in gray. Limits of local temperature changes reflect differences in projected warming in current areas of cultivation. Source: Rosenzweig et al. (2014).

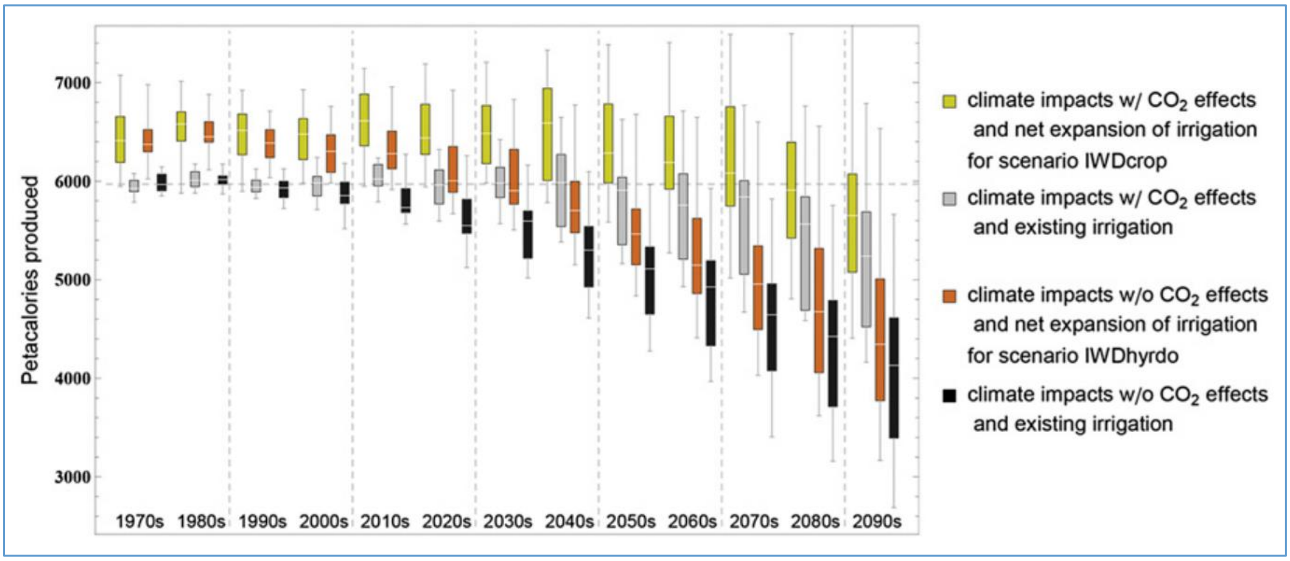


Figure 51- Comparison of the total annual global calories of maize, soybean, wheat, and rice for RCP 8.5 as projected by four sets of ensemble simulations.

The first two sets assume no change in irrigated areas and consist of (i) 30 GCM (Global Climate Models) × GGCM (Global Gridded Crop Models) combinations with CO2 effects and (ii) 22 GCM × GGCM combinations without CO2 effects. The second two sets consist of (iii) 202 GCM × GHM (Global Hydrological Models) × GGCM combinations with CO2 effects and a global net expansion in irrigated areas according to the IWDcrop scenario (based on the median food production units of all GCM x GGCM scenarios), and (iv) 156 GCM × GHM × GGCM combinations without CO2 effects and a global net expansion in irrigated areas according to the IWDhydro scenario (based on the median food production units of all GCM x GHM scenarios). Source: Elliot et al. (2014).

The effects of rising costs of agricultural production will be compounded by growing government requirements to incorporate food-derived biofuels into transport oils. As a result of this trend combined with a growing world population and climate-related challenges, food and farmland prices can be expected to continue to rise. However, over the next 10 years 'global' impacts of climate change on crops will be moderate, but at the local level, regional impacts and unpredictable extreme weather events will have important consequences within this timeframe.

	2020		
	p10	p50	p90
Region			
East Midlands	24.5	51.6	83.0
East of England	34.5	73.0	116.9
Eastern Scotland	0.0	0.0	0.0
London	0.0	0.0	0.0
North East England	4.9	10.0	15.6
North West England	0.0	0.0	0.0
Northern Ireland	1.3	3.5	6.0
Northern Scotland	0.0	0.0	0.0
South East England	17.4	36.7	59.0
South West England	11.8	26.0	42.0
Wales	0.0	0.0	0.0
West Midlands	10.9	23.7	38.3
Western Scotland	0.0	0.0	0.0
Yorkshire and Humberside	15.7	33.1	52.9

Figure 52
Marginal changes due to climate change for the 2020s in the UK in revenues of wheat (£million/year) compared to 1961-1990 with 2010 prices, including socioeconomic change for prices and land use (but no discounting). p10, p50 and p90 refers to 10%, 50% and 90% probability levels. Source: Defra (2012).

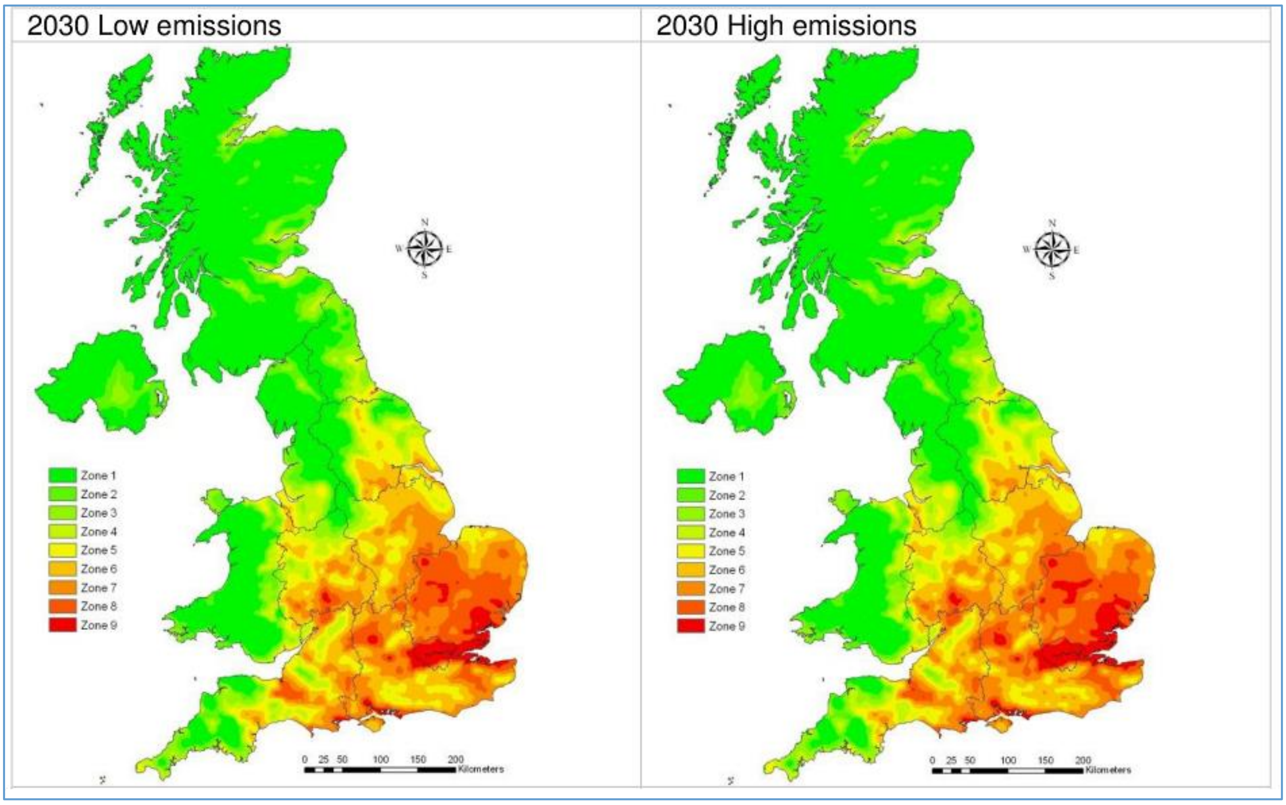


Figure 53
Projected changes in the index of Potential Soil Moisture Deficit (agro-climate) in the UK for selected emission scenarios from the UKCP09. Source: UK Climate Projections (2009), http://ukclimateprojections.metoffice.gov.uk/21678

We argue that commodity markets will be directly affected by climate change as well. Since droughts are arising more frequently, leading to higher food and agriculture product prices, climate change will have direct effects on speculation and trading in commodity futures. Prices for agricultural products and commodity futures will reach a new equilibrium price level above the original one. Generally, in the future we will see a rise in food prices, which will also translate into more predictable futures prices.

For corporations which rely on agricultural products as major inputs, it will become more difficult to hedge against certain changes in crop and food prices, because droughts and extreme temperatures will lead to a generally increased price level. These corporations will suffer from higher input costs which will result in higher end-product prices.

Implications

1. Crop losses and failures will become more common because of droughts and extreme temperatures.

2. Food prices will rise, and while rising generally, local agricultural land prices will either suffer or experience windfall gains as a result of climate change.

3. Food price impacts may have broader political consequences.

4. Commodity markets: Corporations relying on agricultural products as major input factors in their production process will suffer from higher input prices. Hedging against price increases will become more difficult.

5. Conclusion

This report has divided the risks facing the banking sector as a result of climate change into two categories — physical and regulatory risk. These two types of risk consist of direct risks to RBS's assets, and indirect risks arising from their clients' exposure to climate-related hazards. RBS has expressed particular interest in understanding how these risks are manifesting themselves in the real property, energy, transport, and agricultural industries, and consequently what steps can be taken in order to mitigate these risks.

On the physical risk side, it was found that meteorologic (storm) damage represents the greatest risk from climate change, followed closely by hydrologic (flood, drought), and temperature extremes (cold snaps, heat waves). Like all natural disasters, the extent to which climate change will amplify these risks in the next 10 years is uncertain, as is the particular geographies that will be hardest hit. However, the general trend is that climate change will tend to make existing climate-related economic challenges both more severe and more variable. If these trends continue, there may be considerable social pressure for RBS to provide assistance to customers hit by these extreme events.

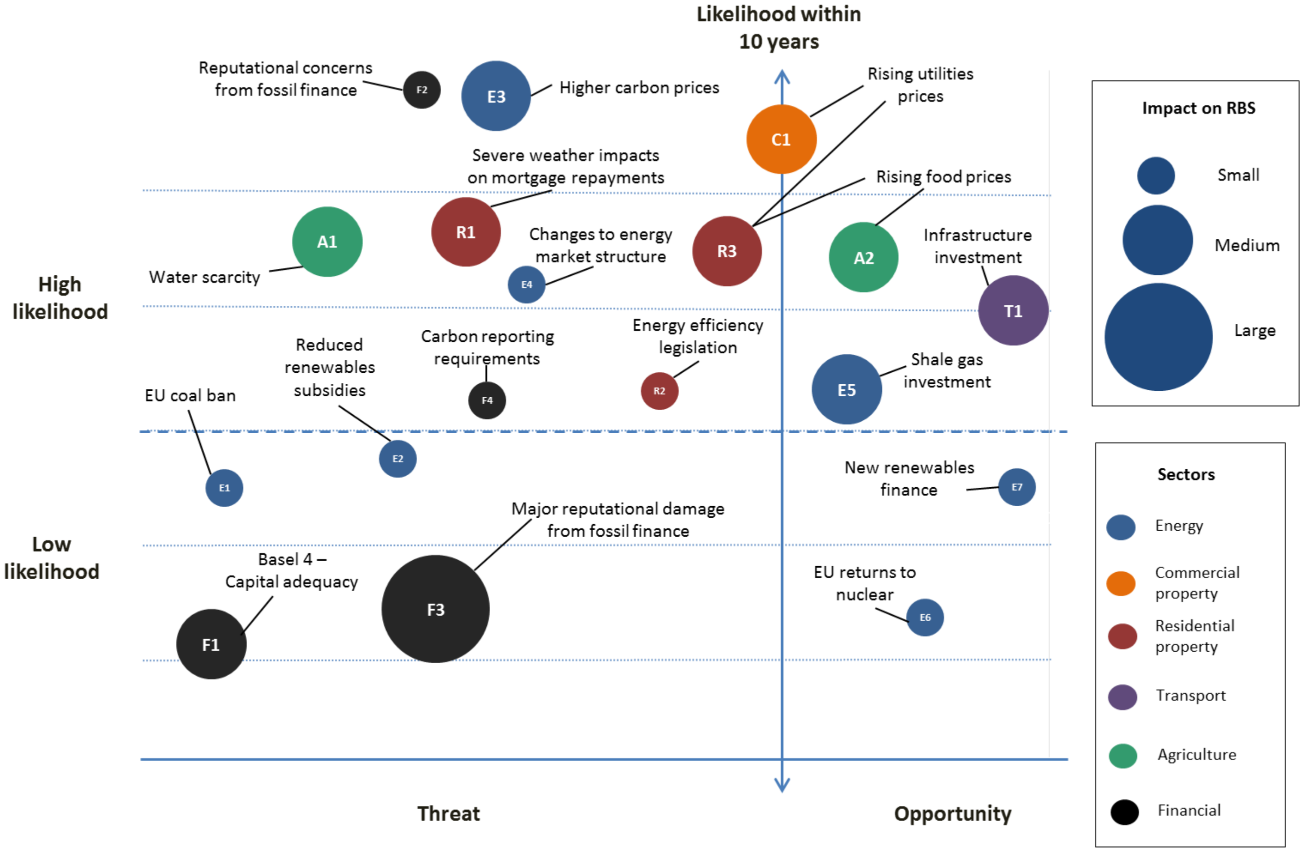
Our assessment is that over the next 10 years however, the greatest direct and indirect climate-related risks that RBS will face are regulatory risks, rather than physical. Over the past 20 years there has been an exponential increase in global climate change-related legislation. This trend is likely to continue for some time, with climate regulations both expanding in countries with few, and deepening in countries with many. Higher carbon prices than at present will prevail, and controls on especially carbon-intensive methods of production will be levied. Furthermore, unsustainable subsidies in renewable energy will be curtailed, but will remain sufficient to sustain continued expansion.

A combination of physical and regulatory risks is likely to increase both the prices of utilities and of food. Utility price rises will be driven by increases in the costs of energy generation and widening water scarcity, while food price increases will occur due to the convergence of a rising population and biofuel mandates with climate-related shocks to crop yields. Utility price rises will affect energy intensive industries and marginal businesses the most, and food price rises may lead to political instability in the developing world.

Public opinion is moving in fits and starts towards the view that climate change represents a clear and present threat to human civilization as we know it. The challenge for business is that public opinion is fickle, and can shift very quickly, especially in response to extreme events. Firms that do not appreciate the seriousness of climate-related risks may suffer reputational damage and an erosion of their customer base, as well as increased regulatory scrutiny and sanction. For firms in the public spotlight like RBS, with interests across diverse industries and geographies, reputational damage represents a considerable risk to the business.

We summarise our view of the primary risks faced by RBS below.

Figure 54. Top Climate Risks and Opportunities for RBS



While ranking uncertain risks is necessarily a subjective exercise, we consider that the top five risks for RBS within the next 10 years in order of materiality are the following:

- **F2/F3: Reputational damage from fossil finance.** We believe that fossil finance simultaneously involves a *high* likelihood of *small* reputational impact for RBS, as well as a *low* likelihood of very *large* reputational damage. For instance, whereas a degree of moderate negative publicity from fossil finance is practically guaranteed over the next decade, a disaster like Deepwater Horizon may produce a disproportionate reputational impact on operators and finance providers. For at least the next 10-15 years, continued global investment in fossil fuels is inevitable, however, and will contribute to raising living standards and prosperity. So the risk of major reputational damage is low. However, the risks from fossil investments will rise as time passes.

- **R3/C1/A2: Rising utility and food prices.** As more renewables come onto EU grids, wholesale prices will fall and become more volatile, and consumers pay levies to cover the renewable costs. This has already noticeably affected the credit of large established utilities in Germany, previously thought invincible, and has strained homeowners' ability to meet mortgage payments. Within the agricultural sector, food price increases transfer value from consumers to producers. This is likely to improve credit of some of RBS's clients in the sector but hurt residential incomes and hence mortgage affordability.

- **E3: Higher carbon prices.** While the UK carbon price floor freeze is likely to remain in place, globally carbon prices are expected to rise between now and 2024. This will reduce the returns from high-carbon investments, potentially even stranding some assets on a longer timescale. It is notable that many of the oil majors and even some banks now quietly use internal carbon prices to manage this risk.

- **R1: Severe weather impacts on mortgage repayments** Physical destruction of assets due to extreme weather will impact on homeowners' ability to repay loans. If properly insured however, all property losses associated with these events are temporary.

- **A1: Water Scarcity** We can expect that increasing local droughts due to climate change will result in water supply interruption, with agriculture the industry most affected.

In order to mitigate these risks, we suggest that RBS consider implementing the following measures;

F2/F3: Reputational damage from fossil finance

1. Reduce investment in the most the controversial carbon-intensive industries.
2. Price loans to fossil fuel industries in proportion to their reputational risk to RBS.
3. Lease office space within high energy performance buildings and facilitate 'green' business work practices.
4. Leverage 'green' business practices and investments in the media to foster a positive social image.

C1/R2/A2: Rising utility and food prices

1. Inform clients of the financial and security of supply advantages of high energy efficiency.
2. Analyse heavy utilities users' solvency against large price rises and resource rationing.
3. Price the risk of energy and food price increases into loans.
4. Consider the effect of food shortages and price increases on political instability in developing regions.

E3: Higher carbon prices

1. Adopt an internal carbon price for business decisions aligned with social optima rather than statutory mandates.
2. Recommend that clients undertake the same.

R1: Severe weather impacts on mortgage repayments

1. Develop a mortgage holiday protocol based on public relations and total repayment advantages.
2. Make sure that special financial assistance can be communicated clearly to customers and the media.

A1: Water scarcity

1. Develop protocols for assessing the regional effects of climate change on agriculture (and other industries), and gauge individual clients' exposure to these.
2. Inform clients of security of supply advantages of high water efficiency investments in dry regions.

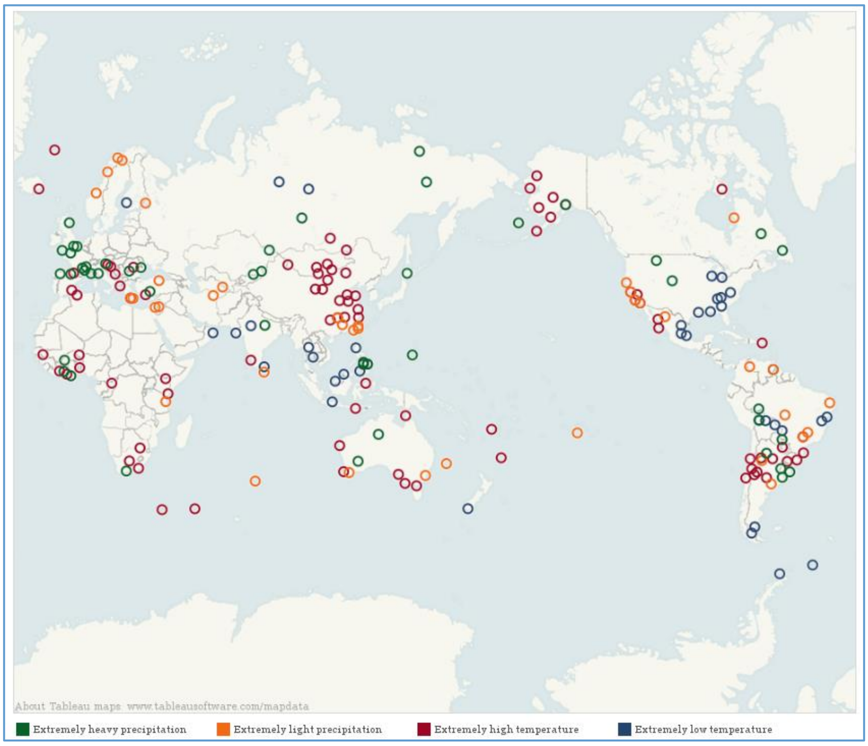
In addition to the aforementioned risks, impacts of climate change will also generate opportunities for RBS. We believe the following opportunities related to climate change will have the most potential for RBS.

1. Infrastructure finance
2. Renewables finance
3. Rising food and agricultural land prices
4. Shale gas investment as a low-carbon bridge
5. Energy efficiency investment and building retrofitting
6. Positive social image as competitive advantage
7. Industry initiatives directing capital towards environmentally sustainable economic activities

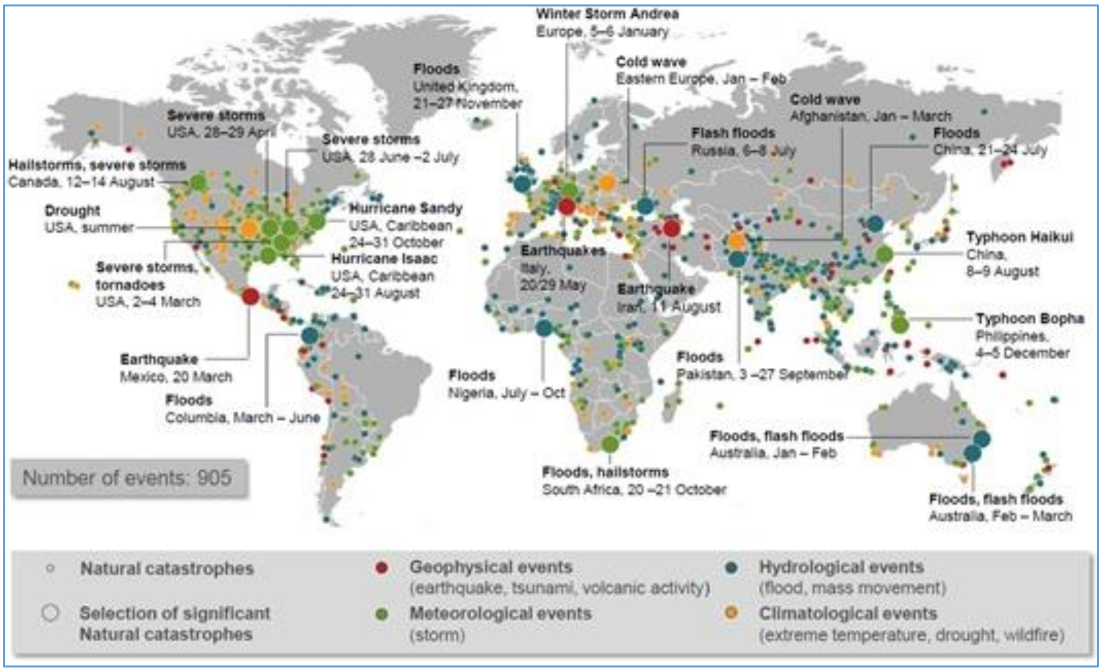
While the physical effects of climate change will remain modest for the next several decades, binding regulations and social sanction are important backdrops to the present business environment, and these influences will continue to grow over time. While presenting a challenge to RBS and the economy generally, if managed properly, climate change impacts also present new opportunities for growth, and for RBS to continue in a strong position into the 21st century.

Appendix

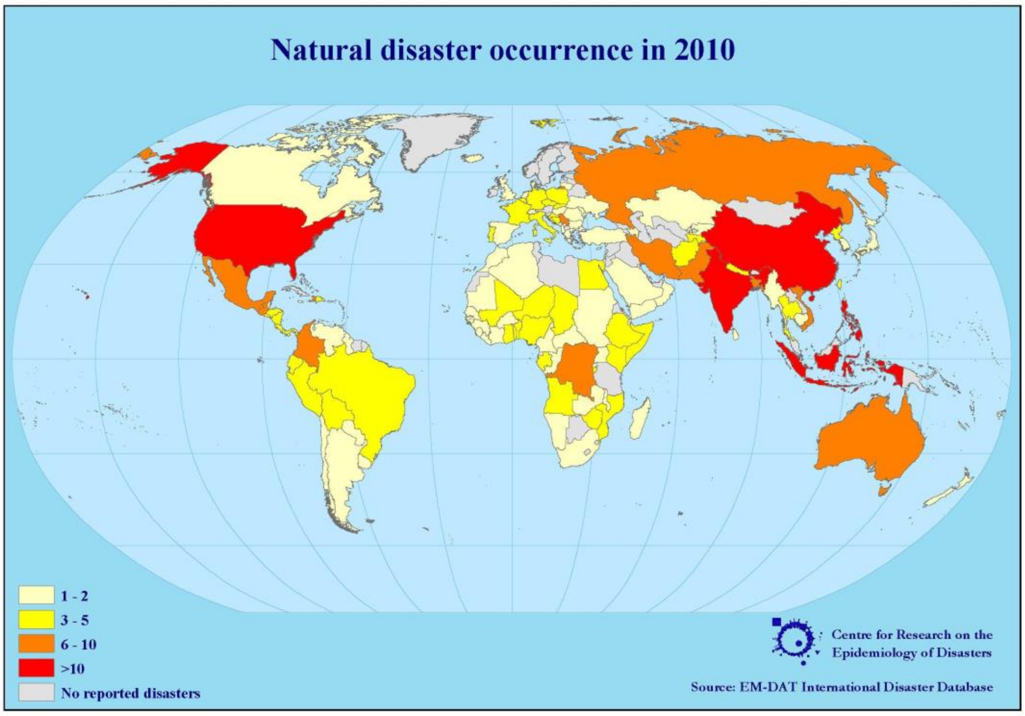
The following visuals illustrate the impact of natural disasters and environmental risks.



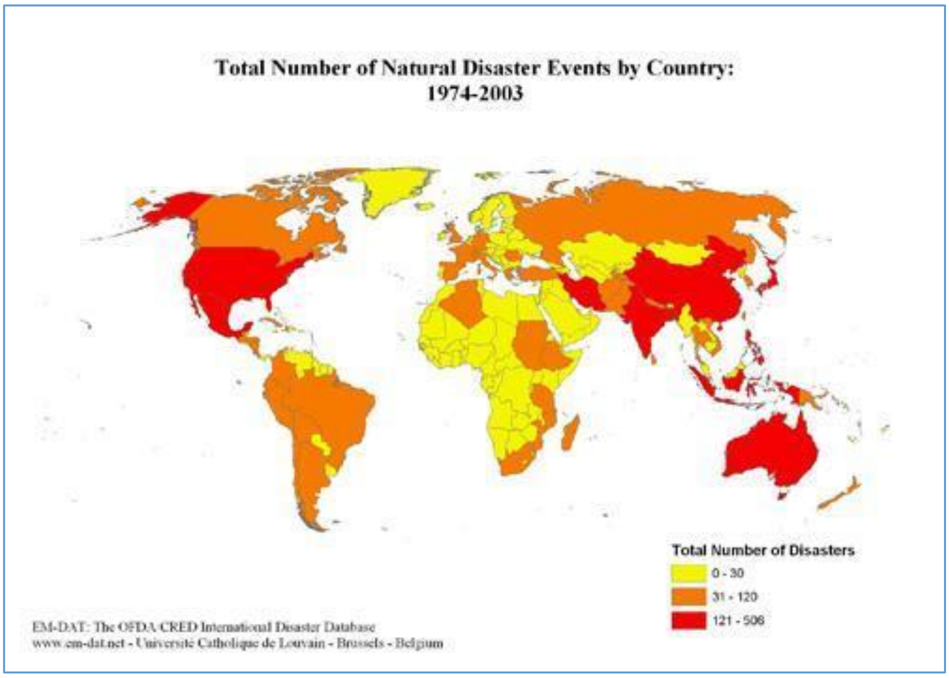
Extreme weather events January 2014
Source: The Guardian and Japan Meteorological Agency



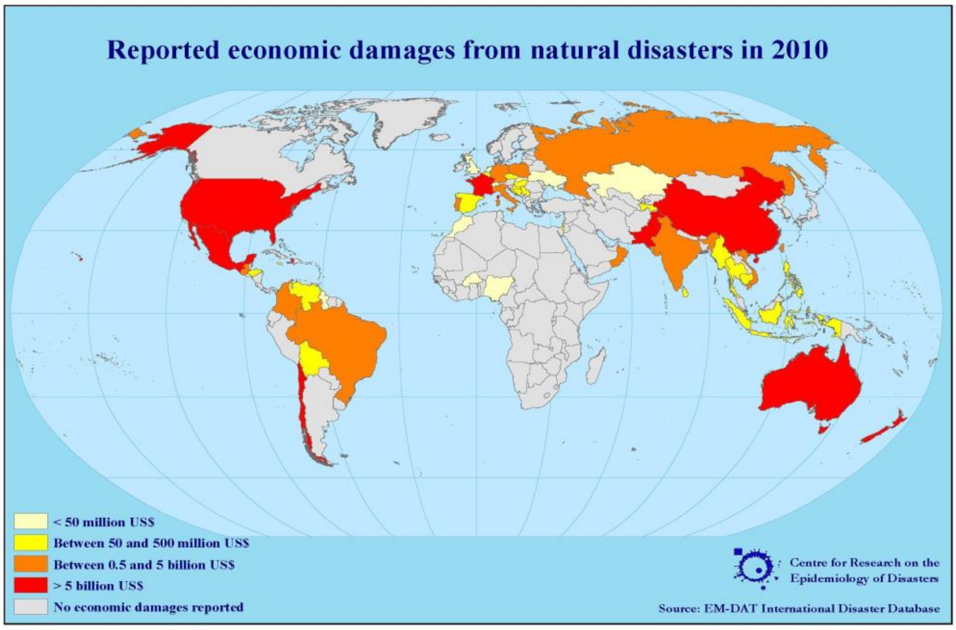
Loss Events Worldwide 2013
Source: Munich RE, NatCat Service



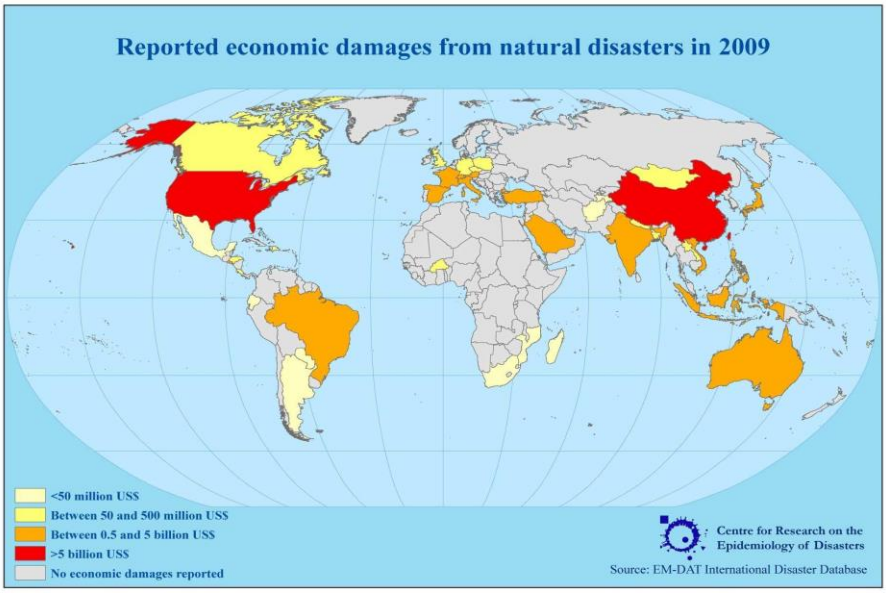
Natural Disaster Occurrence in 2010
Source: EM-DAT



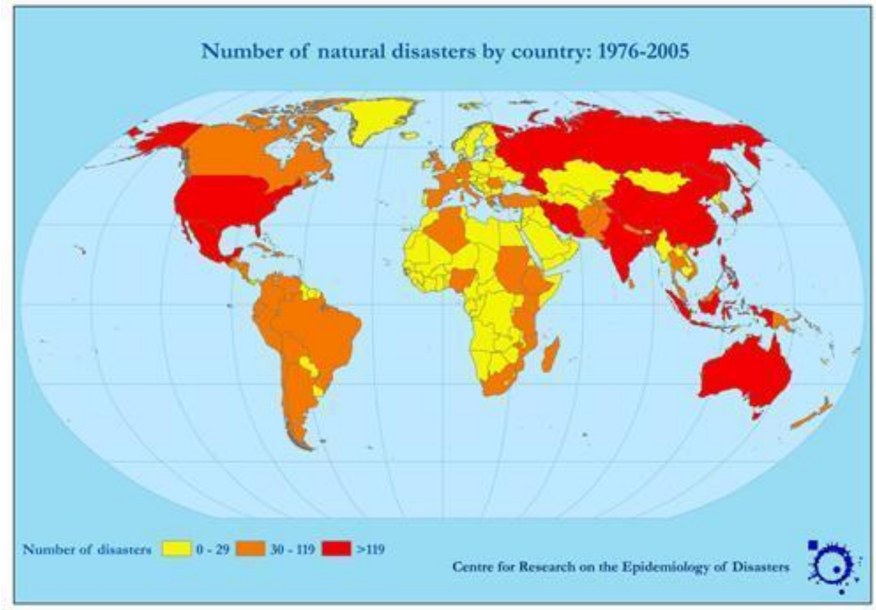
Total Number of Natural Disaster Events by Country 1974-2003
Source: Munich RE, NatCat Service



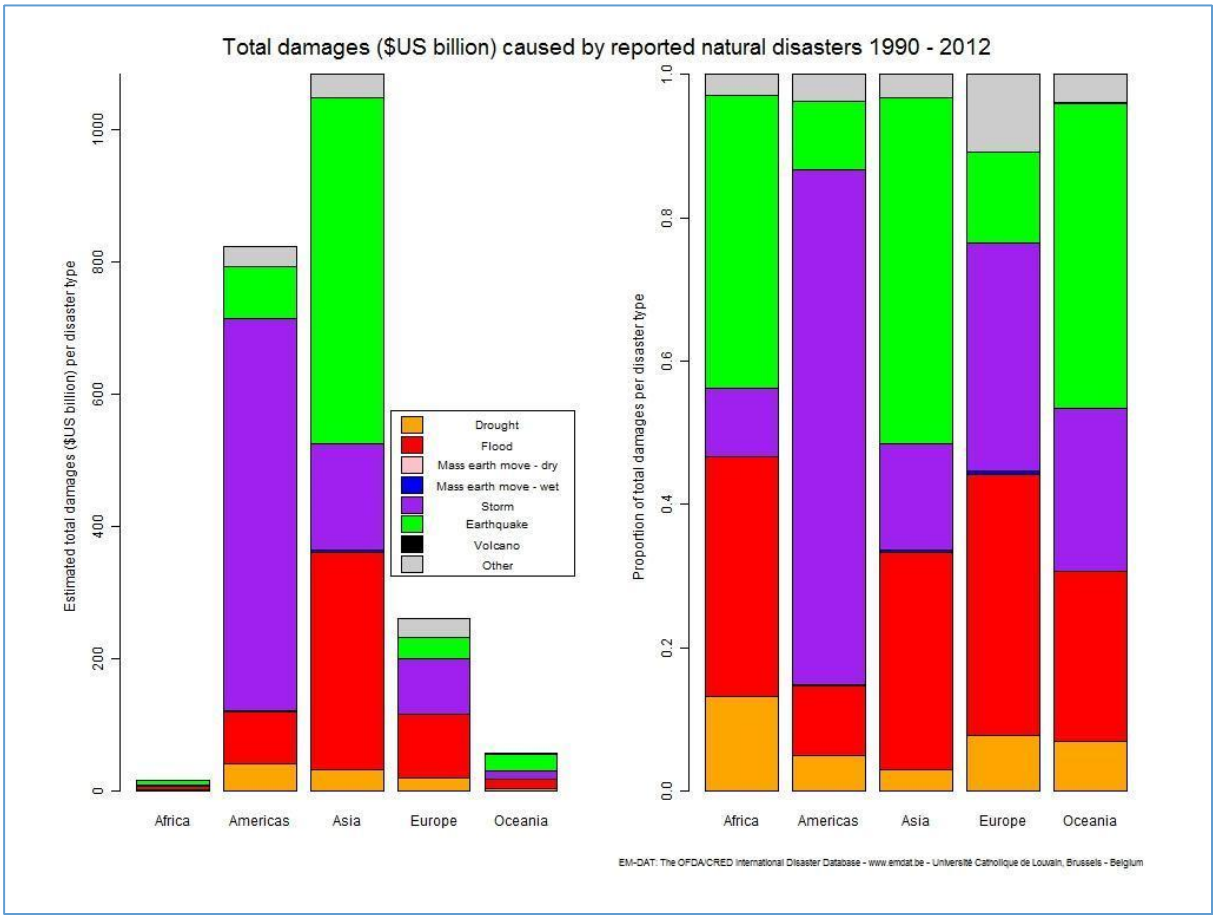
Reported economic damages from natural disasters in 2010
Source EM-DAT



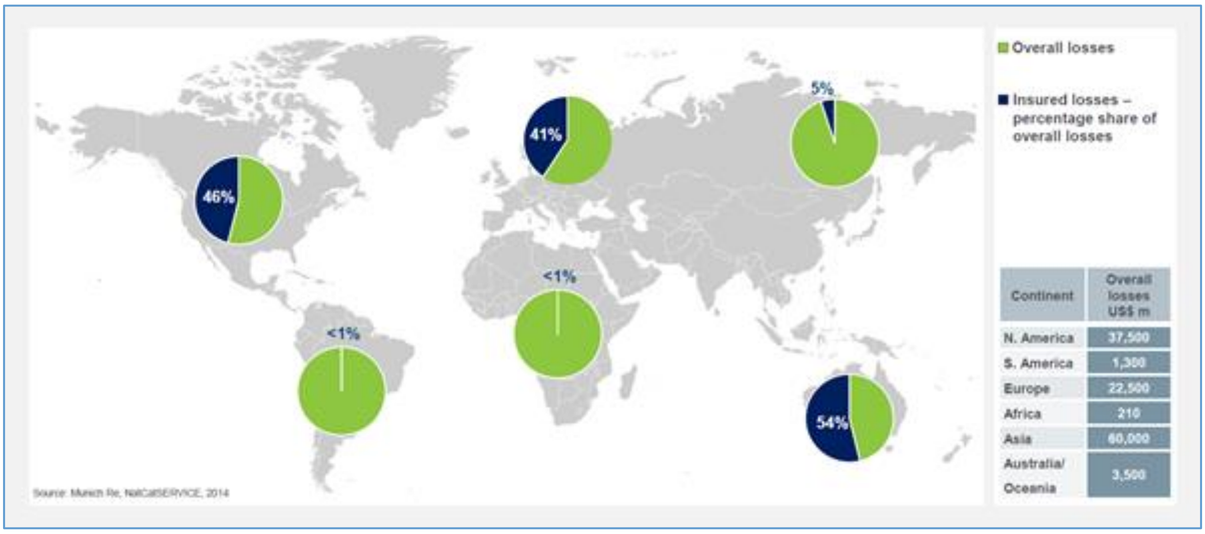
Reported economic damages from natural disasters in 2009
Source EM-DAT



Number of natural disasters by country 1976-2005
Source EM-DAT

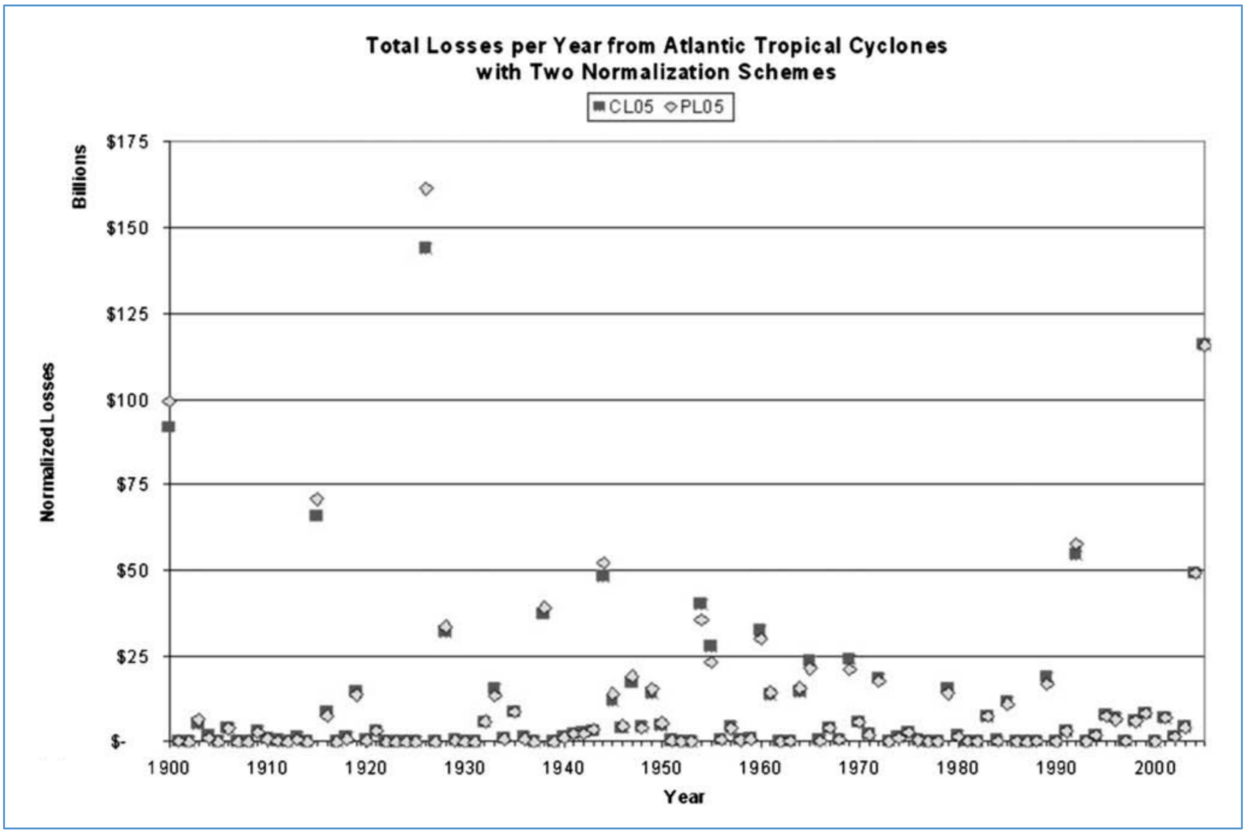


Source EM-DAT

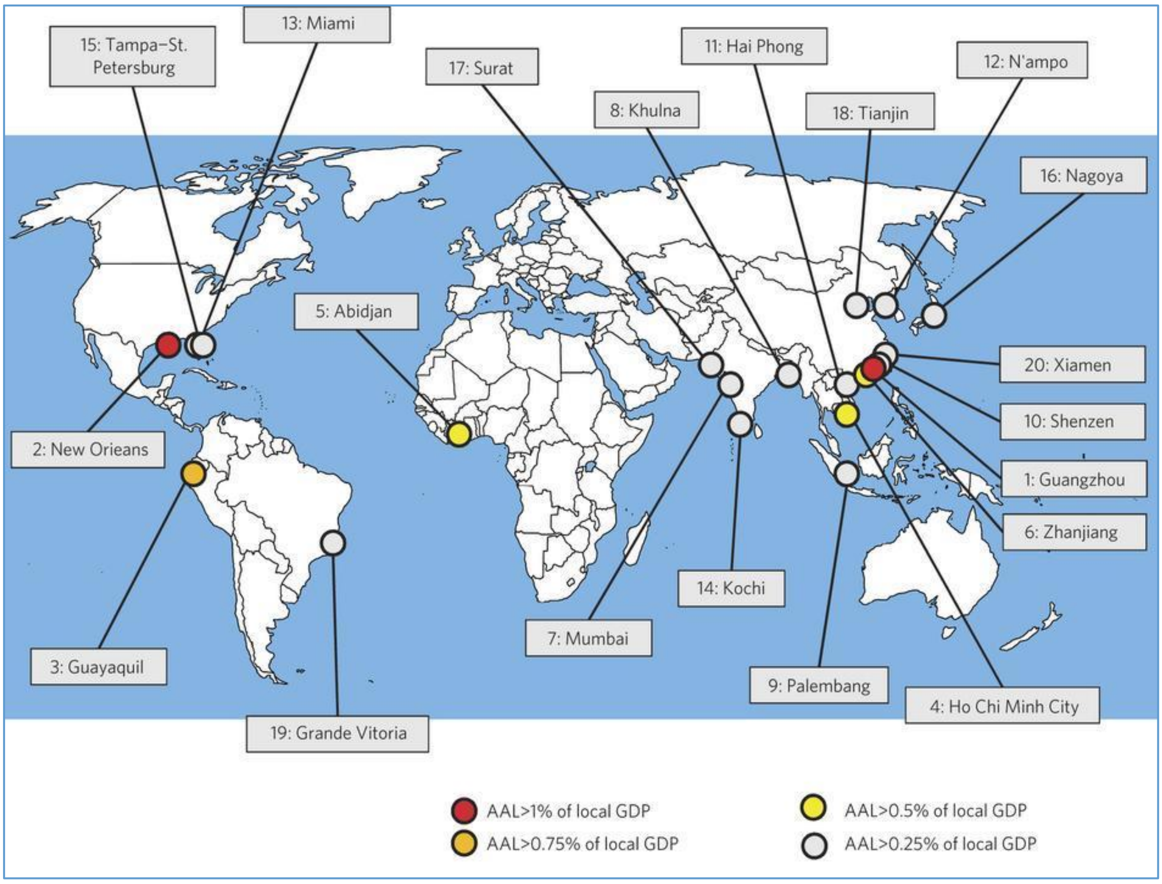


Continent	Overall losses US$ m
N. America	37,500
S. America	1,300
Europe	22,500
Africa	210
Asia	60,000
Australia/ Oceania	3,500

Loss Events Worldwide 2013- Overall and insured losses per continent
Source: Munich RE, NatCat Service



Total U.S. tropical cyclone losses normalized with two schemes. PL05 has into account inflation, wealth per capita and population. CL05 uses housing counts instead of population.
Source: PielkeJr et al. (2008).



The 20 cities where the ratio of average annual losses (AAL) with respect to local GDP is the largest in 2005.
Source: Hallegate et al. (2013)

Ranking by AAL (US$ million)					Ranking by relative AAL (percentage of city GDP)				
	Urban agglomeration	100 year exposure	AAL, with protection (US$ million)	AAL, with protection (percentage of GDP)		Urban agglomeration	100 year exposure	AAL, with protection (US$ million)	AAL, with protection (percentage of GDP)
1	Guangzhou	38,508	687	1.32%	1	Guangzhou	38,508	687	1.32%
2	Miami	366,421	672	0.30%	2	New Orleans	143,963	507	1.21%
3	New York—Newark	236,530	628	0.08%	3	Guayaquil	3,687	98	0.95%
4	New Orleans	143,963	507	1.21%	4	Ho Chi Minh City	18,708	104	0.74%
5	Mumbai	23,188	284	0.47%	5	Abidjan	1,786	38	0.72%
6	Nagoya	77,988	260	0.26%	6	Zhanjiang	2,780	46	0.50%
7	Tampa—St. Petersburg	49,593	244	0.26%	7	Mumbai	23,188	284	0.47%
8	Boston	55,445	237	0.13%	8	Khulna	2,073	13	0.43%
9	Shenzen	11,338	169	0.38%	9	Palembang	1,161	27	0.39%
10	Osaka—Kobe	149,935	120	0.03%	10	Shenzen	11,338	169	0.38%
11	Vancouver	33,456	107	0.14%	11	Hai Phòng	6,348	19	0.37%
12	Tianjin	11,408	104	0.24%	12	N'ampo	507	6	0.31%
13	Ho Chi Minh City	18,708	104	0.74%	13	Miami	366,421	672	0.30%
14	Kolkata	14,769	99	0.21%	14	Kochi	855	14	0.29%
15	Guayaquil	3,687	98	0.95%	15	Tampa—St. Petersburg	49,593	244	0.26%
16	Philadelphia	22,132	89	0.04%	16	Nagoya	77,988	260	0.26%
17	Virginia Beach	61,507	89	0.15%	17	Surat	3,288	30	0.25%
18	Fukuoka—Kitakyushu	39,096	82	0.09%	18	Tianjin	11,408	104	0.24%
19	Baltimore	14,042	76	0.08%	19	Grande_Vitória	6,738	32	0.23%
20	Jakarta	4,256	73	0.14%	20	Xiamen	4,486	33	0.22%

City ranking by risk (AAL) and relative risk (AAL in percentage of GDP) for 2005. (Left column) ranking in terms of AAL, taking into account all potential floods and existing protection. The AAL estimates can be compared. **(Right column)** cities are ranked according to relative vulnerability, namely the ratio of AAL to the city's gross domestic product (GDP). This value can be understood as the share of the city's economic output that should be saved annually to pay for future flood losses. The '100 year exposure' shows the importance of existing flood defences: in a city such as Amsterdam, exposure is extremely high (US$83 billion of assets exposed to the 100-year flood), but AAL does not exceed US$3 million, because estimated defence standards are the highest that exist globally. On the other hand, a city such as Ho Chi Minh, in Vietnam, has a 100 year exposure of only US$18 billion, but the lower level of protection means that the city is affected by small floods on a frequent basis, resulting in large estimated average costs.
Source: Hallegate et al. (2013)

Category of storm	Count	Total damage ($ million)	Mean damage ($ million)	Median damage ($ million)	Potential damage[a]	Percent of total damage	Percent total for each storm
(a) PL05 normalization							
Tropical/subtropical	157	21,843	139	—	0.0	2.0	0.01
1	46	55,172	1,199	158	1.0	5.1	0.11
2	36	80,619	2,239	984	6.2	7.4	0.21
3	58	405,987	7,000	2,828	17.9	37.2	0.64
4	15	449,375	29,958	15,322	97.0	41.1	2.74
5	3	79,266	26,422	21,225	134.4	7.3	2.42
Total	315	1,092,261					
(b) CL05 normalization							
Tropical/subtropical	157	21,267	135	—	0.0	2.0	0.01
1	46	57,602	1,252	167	1.0	5.4	0.12
2	36	80,574	2,238	1,152	6.9	7.5	0.21
3	58	407,088	7,019	3,029	18.2	37.9	0.65
4	15	426,792	28,453	16,297	97.9	39.8	2.65
5	3	79,404	26,468	23,958	143.9	7.4	2.47
Total	315	1,072,726					

Note: The major hurricanes (CAT 3,4,5) account for only 24% of landfalls but 85% of normalized damage.
[a]The potential damage is the ratio of the median damage for a Category X to the median damage for a Category One.

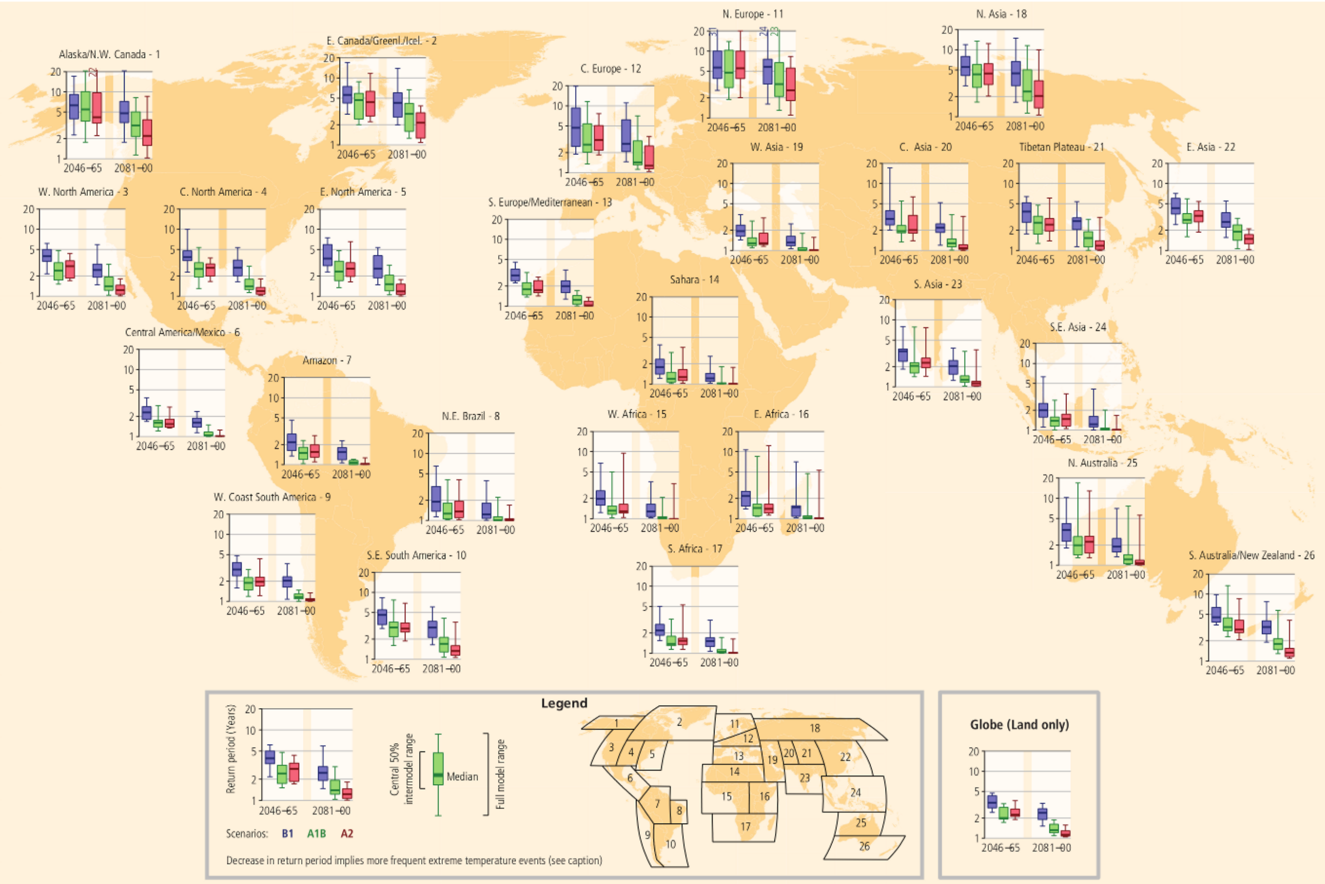
Damage by Saffir/Simpson category of tropical cyclone
Source: Pielke et al. (2008)

Projection		Fluvial flooding	Tidal flooding
Baseline		27	19
2020s	Medium p10	27	21
	Medium p50	32	21
	Medium p90	36	24

Number of electricity substations at significant risk (1:75) of fluvial and tidal flooding in England and Wales for the 2020s (Baseline: 1961-1990) for three different emission scenarios (10%, 50% and 90% probability). Source: DEFRA (2012c) .

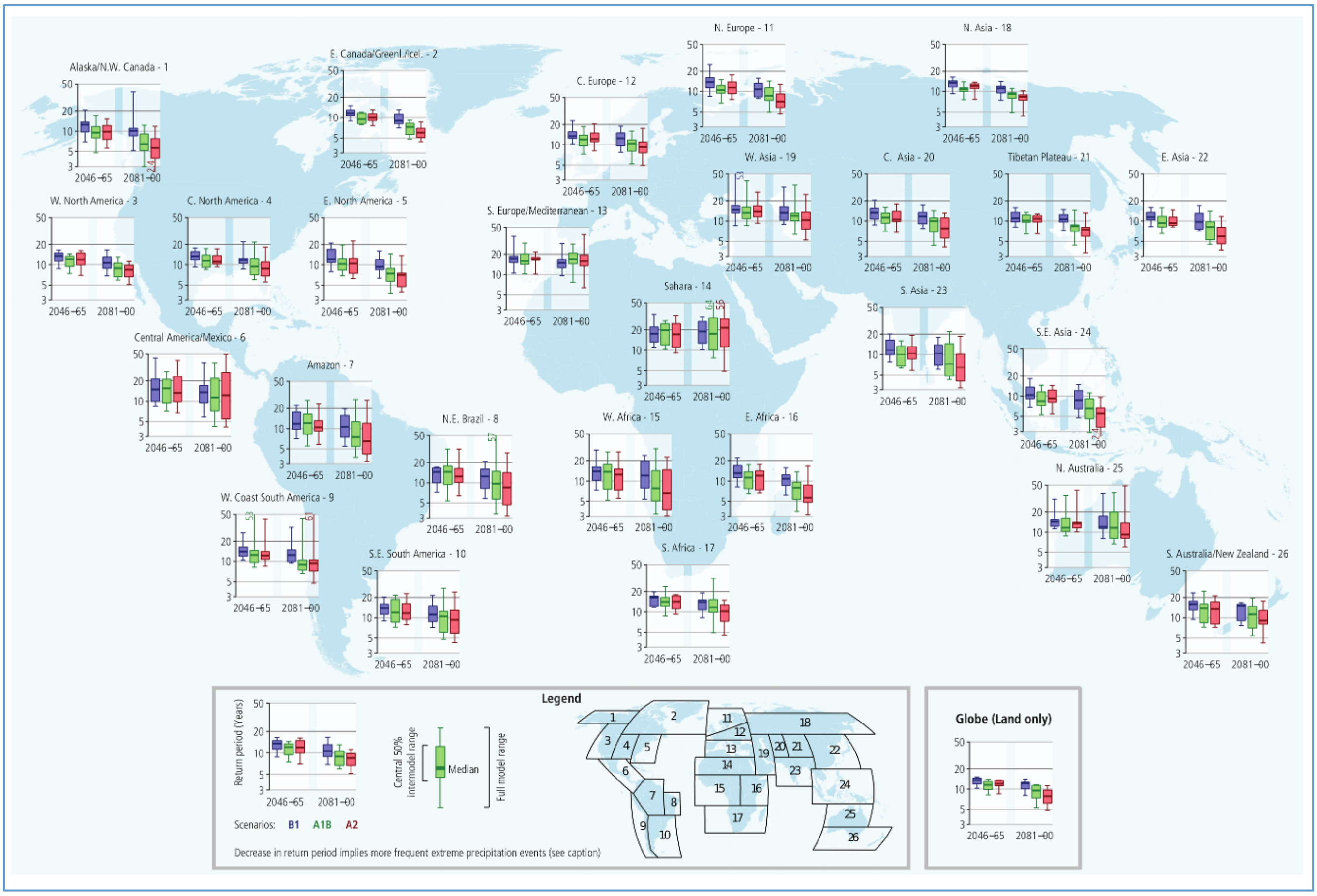
Projection		Fluvial flooding		Tidal flooding	
		Count	Capacity (MW)	Count	Capacity (MW)
Baseline		6	2208	13	8045
2020s	Medium p10	6	2200	15	8750
	Medium p50	9	3600	17	12000
	Medium p90	10	4300	17	12000

Number of power stations at significant risk (1:75) of fluvial and tidal flooding in England and Wales and the sum of their capacities (MW) for the 2020s (Baseline: 1961-1990) for three different emission scenarios (10%, 50% and 90% probability). Source: DEFRA (2012c).



Projected return periods of maximum daily temperature by region.

Projected return periods for the maximum daily temperature that was exceeded on average once during a 20-year period in 1981-2000. The box plots show results for regionally averaged projections for 2046-2065 and 2081-2100, as compared to the late 20th century. Results from 3 emissions scenarios and 12 global climate models. The level of agreement among the models is indicated by the size of the coloured boxes. Source: IPCC (2012)

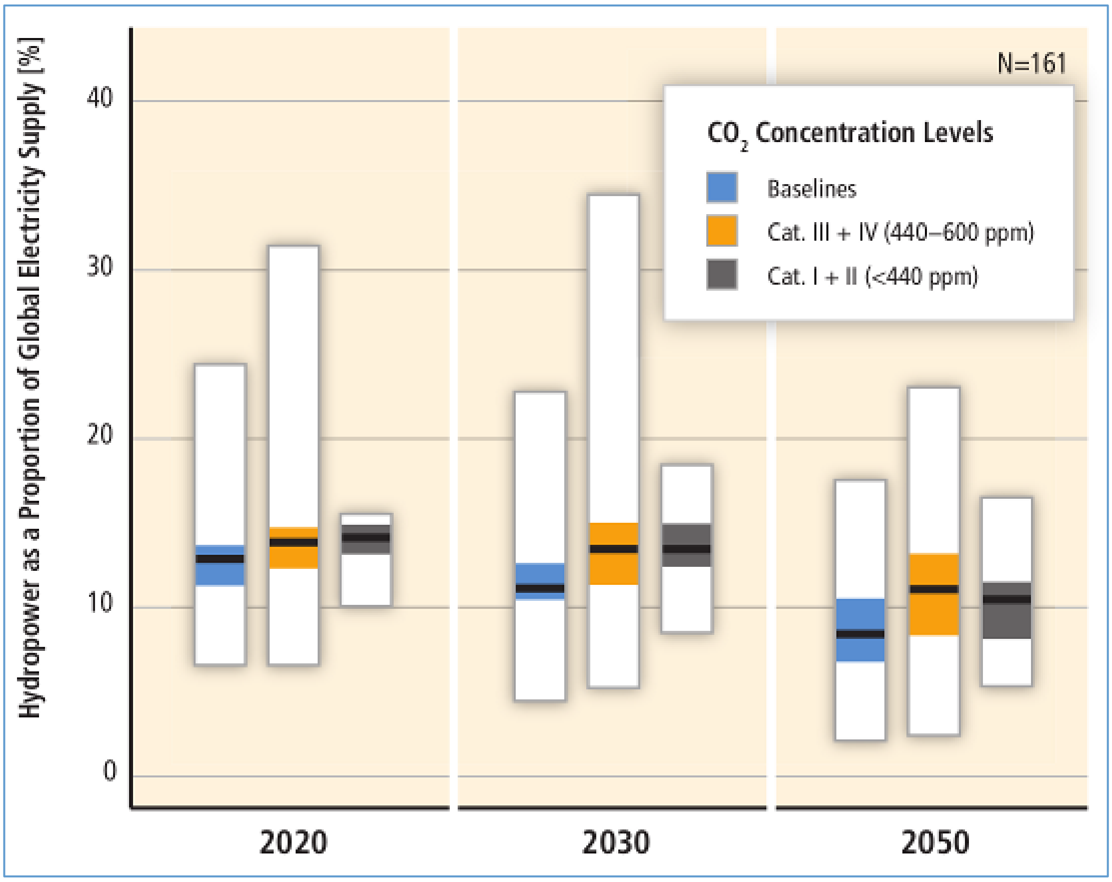


Projected return periods for a daily precipitation event that was exceeded on average once during a 20-year period in 1981-2000.

The box plots show results for regionally averaged projections for 2046-2065 and 2081-2100, as compared to the late 20th century. Results from 3 emissions scenarios and 12 global climate models. The level of agreement among the models is indicated by the size of the colored boxes.

Source: IPCC (2012).

Percentage (2080 respect to 2010 economy) of welfare loss by sectors under different climate change scenarios. Increase in temperature can be used as a measure of temporal evolution, being an increase up to 2.5ºC closer to present day conditions than 5.4ºC.
Source: Ciscar et al. (2011).



Hydropower electricity share of total global electricity supply in the long-term scenarios (median, 25th to 75th percentile range, and full range of scenario results; colour coding based on categories of atmospheric CO2 concentration level in 2100; the specific number of scenarios underlying the figure is indicated in the right upper corner. Source: IPCC (2012b).

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