The Geneva Reports

Risk and Insurance Research

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The insurance industry and climate change – Contribution to the global debate

by The Geneva Association

No. 2
July 2009

The Geneva Association
(The International Association for the Study of Insurance Economics)

The International Association for the Study of Insurance Economics, or by its short name "The Geneva Association", is a unique world organisation comprised of a maximum of 80 chief executive officers from the most important insurance companies in the world (Europe, North and South America, Asia, Africa and Australia). It is a non-profit organisation. Its main goal is to research the growing importance of worldwide insurance activities in all sectors of the economy. It tries to identify fundamental trends and strategic issues where insurance plays a substantial role or which influence the insurance sector. In parallel, it develops and encourages various initiatives concerning the evolution—in economic and cultural terms—of risk management and the notion of uncertainty in the modern economy. The Geneva Association also acts as a forum for its members, providing a worldwide unique platform for the top insurance CEOs. It provides a framework for its members to exchange ideas and discuss key strategic issues, especially at the General Assembly where once per year the top insurance CEOs gather. The Geneva Association serves as a catalyst for progress in this unprecedented period of fundamental change in the insurance industry. It seeks to clarify the key role that insurance plays in the future development of the modern economy.

The insurance industry and climate change

Contribution to the global debate

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July 2009

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The Geneva Reports - Risk and Insurance Research
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Published by The Geneva Association (The International Association for the Study of Insurance Economics)
ISSN 1662-3738

"As the economy and society have grown and developed, so too has the insurance industry; what began with marine insurance has expanded to encompass such risks as fire, natural disasters and automobile accidents. Global warming is a new risk which represents a clear business opportunity for the insurance industry. Today, I take the fact that the leaders of the world's insurance companies are holding a conference on the topic of global warming as an indication of the industry's resolve to actively contribute to the fight against global warming."

"I believe that it is when all the world's players take part in combating global warming that we will be able to see results. And it is my hope that the financial industry, including insurance, will actively contribute by serving as an intermediary in the conveyance of funds and information for the different players involved in economic activity."

Shinzo Abe, former Prime Minister of Japan
at The Geneva Association's 36th General Assembly
in Kyoto on 29 May 2009

Acknowledgements

This first report of the CC+I project, published as *Geneva Report* No. 2, was written by a working group of insurance executives and climate change experts, in the period between September 2008 and May 2009. The working group is chaired by Mr Kunio Ishihara, Chairman, Tokio Marine & Nichido Fire Insurance Company and Mr Michael Butt, Chairman, AXIS Capital Holdings Ltd.

The CC+I Project is directed by Walter R. Stahel, assisted for the first year by Ryoichi Nakai. They both coordinated the activities of the working group and the input to the report.

We thank the following authors for their contribution: Ms Stine Bosse, Mr Mathieu Choux, Dr Eberhard Faust, Mr Kim Dyrhauge Hansen, Mr Hiroyuki "Rocky" Hata, Dr Celine Herweijer, Mr Anthony Knap, Mr Patrick M. Liedtke, Dr Robert Muir-Wood, Mr Trevor Maynard, Dr Michael Menhart, Mr Benedikt Rauch, Mr Andreas Spiegel, Mr Rolf Tolle and Dr Koko Warner.

The report was edited under the guidance of Patrick M. Liedtke by Susanne Le Roux and Françoise Jaffré who also did the layout of this publication.

Contents

Foreword

The CC+I Project

At the General Assembly of The Geneva Association held 28-31 May 2008 in Hamilton, Bermuda, the CEOs of the world's leading insurance and reinsurance companies decided to launch a new research project on climate change and its economic impact on insurance (CC+I). This initiative reflects one of the key long-term priority areas of The Geneva Association.

The objectives of the research project are to identify and analyse:

- issues that are of specific relevance to the insurance industry, such as the likely range of future claims costs, new business opportunities and scenario testing;
- external challenges to be addressed at the political, educational and social levels, such as the role of government-specific provisions concerning, e.g. building codes, zoning restrictions, etc.

Reports will target three different audiences:

- the insurance industry: inform industry stakeholders widely about climate change and implications;
- governments/law-makers/regulators: inform about critical issues, show limitations and the need for official (flanking) action;
- the larger public: raise awareness about the role of insurance, insurance implications and improve the image of insurance.

The CC+I Project is directed by Walter R. Stahel, Vice Secretary-General of The Geneva Association and Head of its Risk Management Research, and Ryoichi Nakai, Deputy Manager of Tokio Marine & Nichido Fire Insurance, seconded for a year to The Geneva Association as Deputy Project Director.

At the 2009 General Assembly of The Geneva Association, held 27-29 May 2009 in Kyoto, the members of The Geneva Association decided to continue the CC+I Project for a second year.

Strategically situating the insurance industry

The Geneva Association consists of the CEOs of 80 (statutory maximum) of the world's largest insurers and reinsurers. The reports of the CC+I Project will attempt to

lay out the common ground for the insurance industry on the topic of climate change and its economic impact on insurance. The insurance industry has several options to react internally to climate change, but in order to tackle the issue jointly, it needs to base its actions on guiding principles and key messages.

Fully understanding the economic impact of climate change will enable the insurance industry to better:

- manage its own risk exposure through mitigation and adaptation measures;
- exploit new opportunities in underwriting and sustainable investments;
- help its clients to mitigate risks and reduce losses through providing its knowledge;
- reduce its own moderate contributions to climate change, particularly CO_2 emissions, in daily operations.

Individual insurers competing with each other to find the best solutions have been, and may remain, the most efficient way to apply mitigation and adaptation measures. But understanding the overall picture will help insurers to better manage their own risk exposure, for instance on how to use regionalisation aspects for risk diversification (drought vs. flood risks), and how to position climate change in a holistic risk approach (compared to water shortages, pandemics, earthquakes and volcanoes).

For the insurance industry as a whole, it is helpful to know where we stand today and where we want to be in the future. The following schedule of four levels is derived from sustainable development, adapted to climate change.

Level 0—inactive
- *understanding of social and environmental impacts of business is limited*
- *efforts to address climate change do not exist*

Level 1—reactive
- *awareness of issues is driven by outside parties or uncoordinated interest groups*
- *limited efforts are reactive, public relations-based and/or inconsistent with business goals*

Level 2—proactive
- *understanding business impact and key issue areas relevant to business*
- *progress is recorded via first climate change reports*

Level 3—developed
- *goals and relevant programmes structure climate change efforts*
- *tracking and reporting capabilities are in place*

Level 4—integrated
- *core business strategies address climate change issues*
- *climate change efforts drive risk management, profitability and growth*

Some individual insurers are proactive. However, today's position of the insurance industry is probably best described by level 1: reactive. But what level should the insurance industry aim for and in what time frame?

In the context of this report, we have presumed that level 2 is feasible within the coming year and can best be summarised as the key move towards a low-carbon economy. The insurance industry strives to reach the level 3 of a "developed" approach as soon as possible.

Furthermore, this approach should then be based on broader objectives, such as those of a sustainable economy. The insurance industry will have to identify its natural partners in this shift, and collaborate closely with them.

The insurance industry may need at least two separate strategies for:

- industrialised countries, where the main sustainability objective is to achieve economic wealth with much lower material and energy throughput, that is, with much higher resource efficiency. Few insurers are today involved in efforts to promote resource productivity,[1] which would also help to strengthen the societal and economic resilience to climate change;
- developing countries for which the United Nations Millennium Development Goals are one of the pathways to reach an increased sustainability.

Monitoring the change

What are the practical steps to monitor the shift? The 10 following steps are taken from a 1984 publication on environmental excellence[2] and adapted to climate change. Some steps can be structured and sketched out, for instance by The Geneva Association, for the insurance industry as a whole, but most will need to be developed and executed by individual insurance companies.

Ten steps to climate change excellence

1. **Develop and publish an "economic impact of climate change" policy.**
2. **Prepare an action programme.**
3. **Organise and educate staff.**
4. **Allocate adequate resources.**
5. **Invest in science and technology to reduce the "economic impact of climate change".**
6. **Educate and train stakeholders.**
7. **Monitor, audit and report industry greenhouse gas emissions.**
8. **Monitor the evolution of the climate change agenda.**
9. **Contribute to climate change programmes.**

For insurance companies that publish an annual Corporate Sustainability or Governance Report, the evolution of these steps could be included in this report. Other companies could publish it as part of their website communication items.

[1] Efforts such as the World Resource Forum (WRF) in Davos; the Brussels based Resource Efficiency Alliance of the European Partners for the Environment (*www.epe.org*), and UNEP Nairobi in 2009.

[2] '10 steps to environmental excellence', in RSA (1987).

Working group and reviewers

This first report of the CC+I Project, published as *Geneva Report* No. 2, was written by a working group of insurance executives and climate change experts, in the period between September 2008 and May 2009.

The working group was chaired by

- Mr Kunio Ishihara, Chairman, Tokio Marine & Nichido Fire Insurance Company, and
- Mr Michael Butt, Chairman, AXIS Capital Holdings Ltd.

and consisted of

- Ms Stine Bosse, CEO, TrygVesta, Ballerup
- Mr Mathieu Choux, Catastrophe Risk Manager, AXA Group Risk Management, Paris
- Dr Eberhard Faust, Head of Research, Climate risks and natural hazards, Geosciences, Munich Re, Munich
- Mr Kim Dyrhauge Hansen, Strategy and Planning Consultant, TrygVesta, Ballerup
- Mr Hiroyuki "Rocky"Hata, Manager, Corporate Planning Department, Tokio Marine & Nichido Fire Insurance Company Ltd. Tokyo
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- Mr Ryoichi Nakai, Deputy Project Director, The Geneva Association, Geneva
- Mr Andreas Spiegel, Vice-President, Risk Management and Senior Climate Change Advisor, Swiss Re, Zurich
- Mr Walter R. Stahel, Project Director, The Geneva Association, Geneva
- Mr Rolf Tolle, Franchise Performance Director, Lloyd's London
- Dr Koko Warner, Head of Climate Adaptation and Social Vulnerability Section, UNU-EHS, Bonn

The first draft report was submitted to a number of outside reviewers for comments and review, in addition to being reviewed by the working group members.

The following experts accepted to act as outside reviewers for parts of the report:

- China Insurance Regulatory Commission, Beijing
- Dr Andrew Dlugolecki, Consultant, U.K.
- Dr Bernhard C. Fink, Member of the Board of Glacier Re, Pfäffikon, Switzerland
- Mr Paul Giles, General Manager Communications, Insurance Council of Australia, Sydney
- Prof Reto Knutti, Institute for Atmospheric and Climate Science ETH Zurich

- Mr Jean-Sébastien Lagacé, Head of Group Covers & Catastrophe Modelling, AXA Group Risk Management, Paris
- Dr Evan Mills, Ph.D., Staff Scientist, Lawrence Berkeley National Laboratory, Berkeley
- Dr Roger Pielke, Jr., Professor of Environmental Studies, University of Colorado, Boulder
- Dr Thomas Schubert, Head of Risk Management, German Insurance Administration, Berlin
- Mr Masao Seki, Associate Director, Corporate Social Responsibility Office, Sompo Japan Insurance Inc., Tokyo
- Dr Swenja Surminski, ACII, Policy Adviser Climate Change, Association of British Insurers, London
- Mr James Wallace, Corporate Responsibility Manager, RSA, London
- Dr Astrid Zwick, Allianz SE, Sustainable Development Manager, Allianz Social Opportunities, Munich

Our appreciation goes to all these experts; their ideas and time have made it possible to write and edit this first report of the CC+I Project of The Geneva Association. The report was submitted for approval to its members at the 2009 General Assembly held in Kyoto, Japan, on 27-29 May 2009.

Moving forward

The CC+I Project has now moved into its second year. It is very encouraging to see how seriously the insurance industry is taking climate change issues and how active it is becoming. A highlight will be the participation of The Geneva Association at the Conference of Parties, COP15, to be held 7-18 December 2009 in Copenhagen. The roadmap thereafter will be strongly influenced by the outcome of the Copenhagen meeting.

The programme and process will be continuously documented in the climate change section of The Geneva Association website, at

www.genevaassociation.org/Home/Climate_Change.aspx

Geneva, 12 June 2009
Patrick M. Liedtke and Walter R. Stahel

ジュネーブ協会 京都宣言

Kyoto Statement of The Geneva Association

The latest climate science strongly indicates that climate change is happening, mankind's influence is very material and the changes are occurring faster than earlier projected. The prospect of extreme climate change and its potentially devastating economic and social consequences are of great concern to the insurance industry. Against this backdrop, we, the leaders of the world's largest insurance and reinsurance companies as assembled in The Geneva Association, want to make known our view through the following key messages.

Customers

- We are committed to enhancing our research capabilities in order to provide a better evaluation and management of climate risks.
- We promote mitigation efforts by developing products which incentivize offsetting or reducing greenhouse gas emission levels.
- We are willing to design insurance products to support low-carbon energy development projects and to help attract investments to such projects.
- As a major institutional investor, the insurance industry encourages mitigation and adaptation efforts, such as investing in low-carbon energy projects.

Policy-makers

- The insurance industry is prepared to help counter climate risks through active cooperation in implementing building codes or similar means which encourage the use of sustainable practices.
- We offer to work closely with policy-makers on communicating to our customers their climate risk levels, possible strategies of mitigation and adaptation, and in quantifying the financial benefits of those strategies.
- The insurance industry provides innovative solutions for climate risk issues. These include funding relevant research and providing tools to its customers to assess and counter climate risks.
- We recognise the significant benefit of pooling climate risks. We urge policy-makers to collect robust data and make it freely available to allow risk assessment and to facilitate efficient solutions where premiums are risk-based.

United Nations Climate Change Conference (COP15)

- The insurance industry is uniquely positioned to provide specialised services for countries and businesses facing climate risks worldwide.
- Insurers have the expertise to develop a broad range of affordable private insurance solutions for climate risks.
- Insurance mechanisms are an effective tool to promote climate-related risk management and reduction.
- We recognise that no stakeholder can succeed alone in solving the challenges of climate change. Insurance can and should be a strong complementary mechanism in a wider framework of adaptation.

Insurance industry

- We encourage political processes to work towards a better understanding of the potential costs of climate change and the advantages of market-based solutions.
- We continue to work towards further reducing the—relatively moderate—carbon footprint of the insurance industry.
- We are willing to play a major and concerted role in the global efforts to counter climate risks.

The Geneva Association offers a unique platform to pool the knowledge and expertise of the insurance sector. It acts as a hub for expert networking within the industry as well as with external communities. The Geneva Association strives to create opportunities for the insurance industry to join their forces to deal with climate risks where relevant and appropriate.

Kyoto, 29 May 2009

京都、2009年5月29日

Chapter 1
The relevance of insurance to climate-sensitive economic development

Stine Bosse and Patrick M. Liedtke

Climate change is the key challenge for the coming years.

Dr Rolf Schäuble,
Chairman, Bâloise-Holding, Switzerland

The insurance industry has a responsibility to dialogue with stakeholders in harmony.

Mr Masatoshi Sato,
President and CEO, Sompo Japan Insurance Inc., Japan

Key message

Insurance plays a major role for the efficient and sustainable development of modern economies, harbouring expertise that is unavailable elsewhere. It is often the precondition for (economic) action, facilitates new ventures and is intertwined with the most basic human needs and aspirations. The availability of insurance has important positive effects and externalities that go far beyond the purely financial. In relation to climate change, insurance is not only a tool for addressing the immediate risk assessment and risk management challenges before us; it can be a powerful mechanism to discover and incentivize the right behaviour.

1. Insurance and climate change: understanding a complex link

In order to adequately appreciate the complex interaction between insurance and the key issues concerning climate change, the fundamental role of insurance in a modern economy has to be understood. This includes issues such as the role of insurance mechanisms generally, the incentives generated through insurance for market players and individuals to behave in certain ways, the impact of insurance products and services (or their absence) on other industries, etc. This chapter will provide an overview on the key direct and indirect contributions of insurance to modern economies.

Insuring risks in a modern economy is a multi-dimensional undertaking. It is a complex business that interacts with many aspects of our lives. The importance of the insurance industry for an economy can only in part be measured by the number of its employees in a given country, the assets under management, or its contribution to the national GDP. It actually plays a more fundamental role in the workings of a modern society, being a necessary precondition for many activities that would not take place were it not for insurance. Insurance is a key component of economic development and as such intimately linked with climate-relevant aspects. Insurance also plays an important role in uncovering and diffusing information about risks in general. If any industry understands the need to tackle climate issues and the risks involved, it is insurance—the risk industry.

2. The intricate position of the insurer

In order to better understand the contribution of insurance to the modern economy, we have to understand the intricate position that insurers find themselves in when they conduct their business. One of the classical definitions describes insurance as a social or commercial device providing financial compensation for the effect of misfortune, with the payments being made from the accumulated contributions of all parties participating in the scheme. At the core of the insurance mechanism lies this idea about accumulating financial assets for times of potential misfortune. There is a fund in which all insureds will pay an assessed contribution (premium), which is not the same for everybody, depending on the specific risk profile. In return, all those who contribute have the right to ask for an appropriate payment, should an insured event occur. The fund is usually created in such a way that it is highly unlikely that all risks in the scheme are affected at the same time. The insurer determines a premium and pay-out mechanism for everybody contributing to the scheme. He (she) is at the same time a fund manager, an owner and a risk expert. All three dimensions of this undertaking will become relevant later in this report when the insurance and climate change links are explored in more detail.

To comprehend what can be organised in insurance markets, it is necessary to understand this very special position: on one hand, an insurer is a custodian or a treasurer of the established fund; on the other hand, he is the owner of the fund. Through this set-up he has a direct interest in its performance. The two interests cannot easily be aligned. However with the mechanism of insurance and a clear determination of rights, this potential conflict can be managed. When constituting a fund for future claims it is usually so well capitalised that in the event of pay-out there will be some money left over. This money,

that is in excess of what has to be paid, can be drawn on because it is the right as owner of the established fund that permits the insurer to profit in such a way from his activity.

At the same time, the obligation as a custodian of the fund means that the insurer will have to pay out for any claims that meet the pre-established criteria. When dealing with questions of insurability and of insurance market mechanisms, this has to be kept in mind because the insurer always has a basic interest in paying out properly established claims, honouring his function as custodian. This obligation, however, also forces the insurer to act in the proper interest of the other parties that form part of the scheme and that might have future claims. Their participation in the insurance scheme constitutes a potential right to draw on the available funds—and more if need be. A potential shortfall has to be made up by the insurer.

The rights of the participants in the scheme need to be protected too; hence the insurer becomes a champion of those rights. It is thus not sufficient to assume that if an insurer refuses to pay out for a disputed claim, he is doing so merely with her own personal interest in mind. He might actively be protecting the other participants in the scheme as custodian. In other chapters of this report, the custodian function of insurers becomes of special relevance as it is also the direct concern for climate-related risks that drives the industry's desire to proactively deal with climate concerns and any potential changes in the risk structures that go with it.

3. Insurers as risk managers and experts

An insurer also works as a risk manager and risk expert because he has to understand and assess the risks he will accept or decline for the scheme. If somebody buys into that scheme, a new relationship is established and has to be judged as to its merits, not least vis-à-vis the existing participants and their risks. Whenever an insurer accepts a new risk into the scheme, this affects everybody who is already in it. It is not just a decision that the insurer takes and where she has a direct obligation concerning the risk *per se*, he also has an obligation to his other business relations.

For the insurer as risk manager and custodian of a pool of risks, unexpected changes present a fundamental problem when they affect the pay-out scheme. Those changes can be of an economic, legal or other nature, such as climate risks. This is especially true if the economic, legal or natural environments change suddenly in a major way during the period in which risks were accepted and before payments for claims are made. The insurer's liabilities will have already been calculated and the necessary premiums to finance these collected before the change in the system renders these initial calculations inappropriate. In effect, the insurer will then have placed (voluntarily or not) a bet on the development in question. Often, when policy-makers discuss legal changes, directly or indirectly linked to insurance activities, these particular effects on the insurance system are not fully reflected upon by the actors. In a similar manner, climate change—especially when induced by human action—poses a special challenge.

It is here where the changing nature of climate risks directly impacts insurance. As the underlying risks are changing (i.e. increasing due to human action as this report will later explain), insurance companies will have to adapt their conditions and their reserving policies. They will also have to strike a balance between existing risks on their books of business and the new ones they accept. When past risk assessment is overtaken by the

real exposure to new and growing risks, such as those linked to climate change, existing reserves might fall short of future claims. Insurers could then find themselves in a position where past risks would have to be subsidised through new premiums. Insurers try to avoid this, acting out of their own interest as well as that of their existing customers. It is hence in the wider interest of the insurance industry and their customers to get the climate risk equation right and to avoid situations where risks could spiral out of control.

4. Insurance as a dynamic and tightly regulated industry

As stated earlier, the insurer defines the conditions for future pay-out and he establishes some guidelines for behaviour. There is a positive impact too in the contribution that insurance can have on the development of an economy that goes beyond just the risk sharing mechanism. An insurer is of course an entrepreneur: he is looking for new markets, for business models and strategies; he wants to grow the business, to establish client relationships, to create an operational infrastructure. He needs well-educated human capital and a sophisticated business infrastructure. This business infrastructure should ideally be reliable and sustainable to be compatible with the long-term nature of the insurance business. In consequence, insurance invests heavily in these systems to assure an adequate foundation on which to do business. All this leads to positive knock-on effects in other parts of the economy. It also has a positive effect on climate change as the insurance industry is generally interested in a stable environment.

The insurer is also a key transmitter of preferences in a society. Very often, particular insurance schemes are encouraged to compensate for specific behavioural structures that a society believes it should influence. Tax breaks for taking out life insurance, mandatory third-party liability insurance or long-term care insurance are examples. In some cases the insurance coverage is a precondition for other businesses to operate. And sometimes that precondition is not cheap: if one considers operating aircraft, for example, insurance rates are very costly, especially if they cover large commercial aircraft flying over crowded cities. Insuring oil exploration activities or super-tanker transportation of fuels are other examples. This provides a lever for introducing social policies and societal preference into the economy using insurance mechanisms. However, one has to be very careful as the nature of the insurance business is that of a private market activity. Regulatory interference and special constraints have to be carefully balanced with the efficiency of the market mechanisms and the necessary preconditions for any insurer to engage in his entrepreneurial activities.

The insurance sector is subject to very tight regulation; few other industries are as tightly regulated and supervised. This supervision ranges from the initial right of establishment to the types of risks that can be underwritten; it spans from the direct protection of consumers to specific contractual arrangements such as reinsurance schemes and other risk transfer mechanisms and how and under which conditions they are permitted; it comprises the language used in contracts as well as general and special requirements for capital held, etc.

All the above mentioned specificities have to be borne in mind when considering the contribution that insurance makes to the modern economy and what its role is and could be for tackling climate-relevant issues. In many aspects, insurance is unlike any other business and even the similarities with other financial services providers are limited.

5. The size of the insurance industry

So, how large is the world insurance market? According to Swiss Re's *sigma* No. 3/2008 (see table below), total insurance premiums amounted worldwide in 2007 to more than US$4,000 billion. This represented 7.6 per cent of world GDP and over US$600 of insurance premiums per capita.

However, there are significant regional differences. Industrialised countries, where insurance solutions are more readily available and uptake by the general population is more widespread, account for the majority of the worldwide premiums, with a share of close to 90 per cent. In those countries, the insurance premiums to GDP ratio (i.e. the insurance penetration) is very high at more than 9 per cent; as well as the amount of insurance premium per person (i.e. the insurance density), as it reaches US$3,650. In emerging countries, insurance solutions are not as extensive. Total insurance premiums in emerging countries stood at US$422 billion in 2007, which equals a penetration of only 2.77 per cent. The insurance density was very low at only US$74 per capita.

Table 1: Global insurance growth, penetration and density (by region) in 2007

	Premiums (in US$ m)	Real growth	Share of world market (in %)	Premiums in % of GDP	Premiums per capita (in US$)
America	**1,420,534**	**2.7**	**34.21**	**7.59**	**1,576.7**
North America	1,330,674	2.1	32.05	8.71	3,986.6
Latin America and Caribbean	89,860	11.8	2.16	2.61	158.4
Europe	**1,764,047**	**6.4**	**42.48**	**8.34**	**2,057.0**
Western Europe	1,689,405	6.1	40.69	9.21	3,296.1
Central and Eastern Europe	74,642	13.3	1.80	2.79	229.5
Asia	**844,929**	**4.9**	**20.35**	**6.23**	**211.8**
Japan and newly industrialised Asian economies	640,562	1.8	15.43	10.38	3,017.2
South and East Asia	180,761	17.6	4.35	3.12	52.2
Middle East and Central Asia	23,606	12.2	0.57	1.48	76.7
Oceania	**68,889**	**4.0**	**1.66**	**6.58**	**2,061.7**
Africa	**53,810**	**1.0**	**1.30**	**4.35**	**55.9**
World	**4,152,210**	**4.6**	**100.00**	**7.64**	**621.4**
Industrialised countries	3,730,167	3.8	89.84	9.25	3,654.3
Emerging markets	422,043	12.8	10.16	2.77	74.1
OECD	3,669,564	3.5	88.38	8.80	3,011.9
G7	2,933,386	3.2	70.65	9.47	3,965.3
EU, 15 countries	1,610,161	6.3	38.78	9.64	3,860.9
NAFTA	1,348,530	2.3	32.48	8.35	3,062.6
ASEAN	41,166	9.8	0.99	3.15	78.3

Source: Swiss Re (2008), update December 2008.

Emerging markets are often seen as those with the highest growth potential for insurance services and recent figures confirm this: the growth rates for insurance premiums are usually higher than in industrialised countries. For 2007, they amounted to 3.8 per cent real growth in industrialised countries whereas emerging markets displayed growth rates of 12.8 per cent.

Insurance premiums statistics are often divided according to the fundamental characteristics of the business and whether it belongs to the life insurance business or the non-life (or as it is called in the U.S., the property & casualty) insurance business. Although climate change-related risks are by no means only connected to the non-life branches, it is here where most of the impact is already visible, in particular as natural catastrophes fall under this heading. The following table gives an overview of the importance of non-life insurance.

Table 2: Non-life insurance growth, penetration and density (by region) in 2007

	Premiums (in US$ m)	Real growth	Share of world market (in %)	Premiums in % of GDP	Premiums per capita (in US$)
America	**756,637**	**-0.2**	**45.32**	**4.06**	**843.2**
North America	706,116	-1.0	42.13	4.62	2,115.5
Latin America and Caribbean	53,522	11.9	3.19	1.56	94.4
Europe	**649,957**	**1.5**	**38.78**	**3.01**	**741.7**
Western Europe	593,411	0.7	35.41	3.15	1,126.7
Central and Eastern Europe	56,546	12.1	3.37	2.11	173.9
Asia	**217,171**	**5.0**	**12.96**	**1.59**	**54.1**
Japan and newly industrialised Asian economies	146,798	1.8	8.76	2.35	684.7
South and East Asia	52,728	13.4	3.15	0.91	15.2
Middle East and Central Asia	17,645	12.3	1.05	1.10	57.4
Oceania	**33,082**	**0.1**	**1.97**	**3.16**	**990.2**
Africa	**16,150**	**7.1**	**0.96**	**1.31**	**16.8**
World	**1,675,998**	**1.2**	**100.00**	**3.08**	**250.8**
Industrialised countries	1,476,871	-0.1	88.12	3.63	1,435.5
Emerging markets	199,127	11.9	11.88	1.31	35.0
OECD	1,485,773	0.0	88.65	3.54	1,210.0
G7	1,174,643	-0.7	70.09	3.72	1,557.4
EU, 15 countries	556,892	0.6	33.23	3.23	1,294.0
NAFTA	716,319	-0.7	42.74	4.43	1,626.8
ASEAN	14,404	5.7	0.86	1.01	25.0

Source: Swiss Re (2008), update December 2008.

Such important capital flows lead to enormous assets, which the insurance industry controls. The OECD estimates that the financial assets of insurers in the year 2007

amounted to US$6,309 billion in the U.S. alone. For the EU, the Comité européen des assurances (CEA) estimates insurance investments at €6,994 billion for 2006 (latest data available). The enormous relevance of the insurance industry as custodian of these assets and manager of the portfolios to the performance of these economies is evident.

Equally important is the share of direct and indirect employment created by insurance companies. For the EU, the CEA estimated the direct employment alone at close to one million persons for 2007. In the U.S., for 2008 the Information Insurance Institute (III) quotes more than 1.4 million employees at insurance carriers and a further 900,000 at brokers, agencies and similar service providers. With an insurance industry payroll of more than US$183 billion (data for 2006), the insurance sector is clearly one of the top economic sectors in the U.S. and elsewhere, with a high percentage of high-quality and well-paid jobs.

It is obvious that such a large and important sector has an impact through its own activities on climate change. The production of insurance solutions also produces green house gases. Even if the industry uses few raw materials and is a low-energy industry, it can make a contribution to fighting climate change by compensating for its own emissions and reducing its environmental impact.

6. Insurance, capital and economic stability

Insurance is not just about the financial compensation of victims; insurance is also the central part of the capitalisation process of a modern economy. It creates huge capital assets. The Amsterdam Circle of Chief Economists (ACCE), which is coordinated by The Geneva Association, estimated the total share of insurance assets in 2007 to be around 11 per cent of all assets worldwide. The funds handled by insurance, due to the nature of the contracts and the sometimes very long time horizons involved, usually stay in the financial market of a given economy for quite some time. Most often it is not fickle investment capital that rushes around looking for quick gains, as it is oriented towards the medium to long term. It thus plays a special role underpinning the steady growth of an economy.

The insurance mechanism furthermore allocates assets according to market forces where needed, and this in a largely stable environment. It also allows a process of maximising returns according to market forces that are directly related to the existing risk structures. It would be an important step indeed if more sensitivity to climate change risks would convince insurers to be more mindful of their impact when managing their assets. At the same time, insurers have to produce a return on their assets and as market participants looking for profitable investments, they are submitted to the same basic constraints that other investors face. It would be naïve to assume that asset managers in insurance would stop investing in a certain sector solely because of that sector's negative climate impact. As long as external effects on climate change are not fully internalised by those actors responsible for them, asset managers will respond to the distorted incentive to invest.

Another key point is the buffer function of insurance in the modern economy. This buffer function is of great importance for a modern economy because it allows filtering out sudden surges in financial needs linked to a disaster for all insured players that might otherwise be pushed into bankruptcy. The existence of insurance allows forward planning with more certainty, avoiding or mitigating specific risks that are deemed to be threatening to the general business process.

Even when subjected to great stress, the insurance sector has a tendency to be more stable than other parts of the financial services sector, as the current financial crisis has demonstrated. Insurance crises play out in fundamentally different ways compared to e.g. banking crises. In a banking crisis the most feared phenomenon is a run on a bank. The effect is immediate and it has to be stopped otherwise it will destroy the economy as ever more funds are withdrawn and the capacity of the banking system to cope with the reduction in assets deteriorates very rapidly. A major crisis in the insurance sector develops differently as there is less liquidity risk and usually more time to react. Most insurance risks—and that includes most climate risks—cannot be triggered by the policy-holder. Or, such as in the case of risk life, accident or health policies, they will usually not be triggered as they involve grave personal harm. Even in the case of savings products, insurance companies often build in withdrawal costs that stabilize the system in adverse times as it makes the cancellation of policies more costly to the insured.

In the event of an insurance firm becoming technically insolvent it can continue to operate for a certain time (sometimes years) without having to cease its activities. After a major crisis insurers could start paying out claims while recapitalising at the same time and using parts of the premium income for future risks to finance current liabilities. While this is not a desirable situation, both insurers and regulators, would want to avoid it whenever possible, in a moment of utmost stress on the financial system, the resilience is much higher for insurers than for banks due to this flexibility. When it comes to climate risks, however, this mechanism can cut both ways. On the one hand, it is helpful in stabilising the system in the event of a major catastrophe. On the other hand, accelerated climate change could lead to an increasing incidence of extreme events that would continually put the insurance mechanism under pressure as exploding claims could require almost constant recapitalisation.

7. Insurance, savings and risk spreading over time

Insurance is one of the rare mechanisms that allow spreading risk over time. This risk spreading over time can involve very long periods and works even from one generation to the next. There are very few other industries that have as long a time horizon as the insurance industry. Who else would think more than 50 years ahead? Perhaps the builders of a nuclear power plant, but few others. And insurance has to consider periods of up to a century. The French woman Jeanne Calment, who lived to the age of 120, had she taken out a life insurance policy with an annuity component around the time she was 20 years old, this policy could have been in force for about a century.

Insurance has a double positive impact on the savings of an economy: firstly, it increases the general savings rate, especially through the existence of life insurance products but also by creating pools of assets that are meant to cover potential future claims. It thus creates deeper markets and allows for more investments. Secondly, it decreases the level of unnecessary (individual) precautionary savings, which is often not available to capital markets. This stimulates investment and consumption by reducing bound (and therefore unproductive or less productive) capital. Insurance thus helps to provide more working capital to an economy because people do not have to protect themselves against the eventuality of, for example, their home being destroyed by a fire. They just have to secure adequate cover through a fire insurance policy and be ready to pay a much lower

amount of money over a longer period—a totally different mechanism. This means that the money saved in the process can be allocated to other things, more in line with the preferences of the individuals and more productively. In the process, insurance mechanisms transform dormant capital into free capital.

8. The effects of insurance beyond the financial dimension

Insurance plays an important role in the financial domain. However, its impact beyond the purely financial and its impact on economic growth are at least as relevant to a modern economy. When it comes to climate change, the importance of these non-financial functions is of particular significance as we will see in the other chapters of this report.

Insurance, when it is provided, gives independence to people and increases their capacity of self-reliance. The ability to cope with adverse effects, which are often unexpected and might occur at the least opportune moment, is strengthened. This creates a very strong impact on future development because it enables people to become and stay active as they do not have to worry about all possible adverse effects that a certain activity might entail. While there is a direct economic effect through the financial protection of assets, there is also an additional consequence: peace of mind. People tend to behave differently—and we suppose more positively—when they know that certain risks are taken care of. This is a psychological rather than a financial effect accompanying the purchase of insurance. The counter argument here is the existence of moral hazard, where individual behaviour becomes more risky due to an existing insurance coverage. It is difficult to assess the exact impact of both effects, a positive one that reduces risky behaviour and a negative one that would encourage it. Insurance companies have found ways of dealing with the problem of moral hazard by implementing mechanisms that protect the insurance scheme from undue exploitation and bad risks.

Another problematic element stems from the ability of insurance to gather assets through their premium income. These assets sometimes incite legal action that would otherwise not have taken place. Knowing that a party is insured can both provoke a lawsuit in the first place and also drive up possible compensation later. How far a society is served through these processes, or not, is difficult to estimate but insurance plays a major role in the legal production and often ends up settling the costs for lawyers involved.

Once people are insured, they become members of a solidarity group that goes far beyond their own cycles. In the past, a family or village, maybe an extended family or a network of little villages could work together to share certain risks and compensate those that suffered from ill fortune. However, the scope of a risk sharing group was usually limited, if not by geographic realities then by the impossibility of knowing and understanding the risk exposure of an unknown partner. Through insurance however, the risk sharing group can be extended and people who participate in it need not know everybody else in the group as they delegate the task of organising the group to an expert, the insurer. Consequently, the group can take on a whole new extension where risks can be pulled from different parts of the world; even different risks and different lines of businesses. The resulting risk pool is organised *ex ante*, i.e. before a disaster happens, to support the others when and should it happen regardless of the formal ties that participation

in the scheme might or might not share. This is an important mechanism that would not exist at such a sophisticated level without insurance.

As we are contemplating climate-related risks, this mechanism becomes even more significant. It does not help to share risks within a family or among a small group of villages if climate events such as hurricanes and floods can take out the whole group at once. However, when insurance mechanisms can be spread to other areas which are outside the scope of even a very large natural disaster, then they provide a level of protection that would otherwise not exist. Even countries among themselves could share such mega-risks. As climate risks are understood to be linked around the globe, this characteristic of insurance ties in well with the need for creating transnational systems to cope with those (new) risks.

Insurance markets also expose myopic and other irrational behaviour of agents and allow for their correction. Examples for these corrections are often found in the subvention of certain insurance lines and in the existence of mandatory coverage for specific risks, e.g. third party liability cover or health insurance. Insurance mechanisms can play an important role for shaping public policy and helping certain social goals to be established and implemented or reinforced. The problem here, however, is to finely balance any public policy target with the need for insurance mechanisms to properly work in private markets and the opportunity for insurance companies to assess, select and price risks objectively.

9. Insurance as a knowledge industry

Insurance companies are information providers, knowledge carriers and training centres providing highly complex products that need a lot of financial and non-financial knowledge: a fire insurer needs to know about building codes and materials, a flood insurer about geographic features and meteorological conditions, a health insurer about medicine and pharmacology, etc. This bundling of specialist knowledge has a positive effect on and is of significant value to the development of economies and societies.

Firstly, insurers need well-formed experts in risk matters that work for them and so they have an interest in the education and formation of an experienced workforce. Through their work and the specialists needed to run their business, better understanding about risk issues is introduced into society. Secondly, they create more knowledge about risk management, risk assessment and understanding vulnerabilities on the side of their potential customers, consulting, for example, about risk exposures and prevention, mitigation strategies and possible solutions. The sale of an insurance product is closely tied to a risk assessment exercise by the insurer, which is usually shared with the prospective client.

This introduction and spreading of knowledge and understanding is obviously strongly present where climate-related issues are concerned. For many years, insurance companies have been a driving force to study and understand climate change and have invested heavily in exploring the links between certain (natural or human-made) activities or developments and their impact on insured and uninsured risks.

The pursuit of better knowledge by the insurance industry in all fields is valuable not just for the insurance markets, but for the general development of the economy because risk assessment, risk management, prevention mechanisms, etc. are very much a precondition of and a driver for sustained growth. And its absence, as we all too often find out, can

be disastrous for many undertakings. Overcoming a lack of understanding about climate change and the accompanying changes in risk exposure would be a step forward for any country aiming at long-term development.

10. Insurance and behavioural impact

It is interesting to note the high correlation between the existence of insurance in certain markets and the profusion of preventive measures. This apparently not only affects those parts of the economy where insurance is active but also in a more general way as certain risk management practices spread and are more widely adopted. Even legislators seem to react to this mechanism because more sophisticated legislation tends to appear in tandem with more sophisticated insurance markets. While this conclusion is merely based on observation, it seems robust across a series of countries and at various stages of development.

Insurance not only affects *ex ante* behaviour such as more efficient prevention, but also *ex post* behaviour. The information and knowledge that exist through insurance allow for example speedier reconstruction after natural or man-made disasters. Knowing that the affected parties have insurance policies that cover an event and assure enough funds to sustain rebuilding efforts, the work on a disaster site becomes more attractive or even possible in the first place. Larry Silverstein, the owner of the World Trade Centre in New York that was destroyed in the attacks of 11 September 2001, made a very clear case for reconstruction. He said that the availability of the insurance pay-out was directly linked to his reconstruction effort.

But it is not only the pay-out that has an effect. Already the understanding by all parties that a risk is covered leads to positive results. Consider another example: after a hurricane, if it is known that homeowners have the money to pay for new roofs, the construction companies are ready to provide the services because they know that they are going to be paid eventually. This means that the existence of an insurance scheme creates another reservoir of activities, of services that are ready to step in, in case of a disaster. They would not be available as a back-up if people lost everything due to a disaster and did not have the opportunity to rebuild.

The existence of an insurance market fosters an industry around it: offers for preventive measures and services, damage assessments, legal advice and assistance, claims handling services, relief and reconstruction mechanisms, etc. These services are not only available to the insured but benefit the whole economy. They also create many jobs, much like the insurance industry does. Work in the insurance industry is quality work, as insurance jobs are generally high-skilled modern services workplaces with low absenteeism and few accidents. They are well-paying jobs for a large number of persons with varied backgrounds.

Insurance also has a very positive interaction with the public domain because major incidents could result more easily in large disruptions and even in civil unrest in the absence of mechanisms to compensate the affected population. The aforementioned 11 September attacks caused economic losses to the city of New York in the order of US$100 billion, as calculated by McKinsey. The insurance pay-out is estimated by Swiss Re and Munich Re to be around US$30 billion, a significant share of it in the form of life insurance payments to distressed families who lost their prime income-earner, or in the form of

business interruption policies which guaranteed continuing income despite the loss of a key source of revenue for shop owners and other entrepreneurs. It is only too obvious that these pay-outs helped mitigate the effects of the disaster on the general population. As the New York experience showed, after large disasters, the insurance infrastructure allows for easy piggybacking of additional initiatives like impact assessment and information sharing, public disaster information and relief centres, the channelling of humanitarian help, etc. The disaster relief centre, created by the III in New York, grouped and coordinated 25 different organisations, all with the aim of helping people and businesses to cope with the aftermath of the terrible event.

The counter-example to this positive post-catastrophe scenario could, to a certain extent, be the aftermath of Hurricane Katrina which struck New Orleans in September 2005. The storm and the floods that followed not only took hundreds of lives but they also destroyed the livelihood of many people and families who had no protection in the form of insurance. In addition, the insurance infrastructure in the State of Louisiana was much inferior to that of the State of New York in 2001. The violence and looting that took place in the days after the hurricane could be linked, at least in part, to the fact that very few of the poorer families could expect insurance pay-outs to help them reconstruct their lives.

As we can easily observe, the existence of insurance and the protection and prevention schemes that go with it have a noticeable impact on public life. They also play a specific role when it comes to climate risks. People will generally not accept the same lax attitude towards risk management by governments if they are fully aware of the consequences. The nuclear debates in the 1970s took a different turn when the high risks associated with this technology became more apparent and publicly known. Insurers and their business partners provide much of the knowledge concerning climate change and natural disasters like storms and earthquakes. Through their work the public risk debates are different, usually more informed but also more intense, and they often play a direct role in stimulating less risky behaviour. Safety campaigns like "Safe driving" or "Safety at Work" are very positive as they aim to reduce fatalities and accidents. In France, a recent nationwide safe driving campaign was supported in a major fashion by the Fédération Française des Sociétés d'Assurance (FFSA), the French insurers' association. It reduced road fatalities by about a quarter in less than one year![3]

Insurers are sometimes considered as very boring because they want people to buckle up in their car and they do not want them to take risks recklessly. People can still decide not to buckle up (even though they would have to pay a fine in most countries) but at least they are aware of the dangers and that this sort of behaviour is becoming less acceptable and less common. The possibility of associating insurance premiums directly with the risk exposure, especially where individual behaviour plays a major part, is a powerful tool. The awareness about insurance premiums going up because of risky behaviour is not lost on the cost-conscious consumer—with a generally positive result for the economy at large.

[3] It has to be noted, however, that not all those campaigns lead to positive results. Sometimes they have no impact and in rare circumstances people get used to certain risks, disregarding safety issues. Our societies generally accept for example, a high number of road accidents and even fatal incidents that would lead to a public outcry if other activities were concerned. Hopefully climate change will not spark a similarly passive and disinterested reaction or false tolerance vis-à-vis the impairment and loss of human lives.

11. Conclusion

Insurance is unfortunately often considered as an unnecessary expense by potential buyers, particularly if they are uninformed. It is also seen by economists as a superior good, which becomes regularly and widely available only after many other needs are covered. This is wrong! Insurance is not an unnecessary expense, but if done right, an investment in the protection of assets and activities. It is not a superior good in the sense that it is a luxury and should only be considered after many other matters; it is often the precondition for (economic) action and it is intertwined with the most basic human needs and aspirations. The availability of insurance has important positive effects and externalities that go far beyond the purely financial. In many cases, being uninsured is in the long-term the most costly option—to an individual, to an economy, to a society. This is especially true for climate risks.

This chapter has described the positive role and impact that insurance has in a modern economy. Unfortunately, many of the above constructive and helpful effects are neglected or not fully considered in all their ramifications when it comes to policy decisions. Despite the existence of mutuality and risk-sharing schemes for hundreds of years, and, in its modern form for arguably more than a century, insurance is still not fully understood by all key stakeholders. This is not only a misfortune from an intellectual point of view but a real waste of possibilities to develop modern economies in the most efficient way. When it comes to climate change, the insurance industry has much to offer. At the same time, other aspects of our social and economic decision-making processes on climate change will have to better take into account the extraordinary variable that insurance represents in the future interaction between humans on this planet and its climate.

Chapter 2
Physical effects of climate change from an insurance perspective

Eberhard Faust, Celine Herweijer and Anthony H. Knap

Perhaps no industry is more aligned with the world's self-interest in preventing the destructive effects of climate change than the insurance industry.

***Mr Mike McGavick**,*
CEO, XL Capital Ltd., Bermuda

The insurance industry definitely has a role to play in climate change adaptation.

***Mr Ignacio Eyries**,*
CEO, Caser Group, Spain

Key message

Anthropogenic climate change has accelerated in recent years. The burden of losses due to more frequent or intense extreme events will rise over the coming decades. Current fossil fuel emissions match the upper bound of the range of emission scenarios defined by the Intergovernmental Panel on Climate Change (IPCC), which can be perceived as a harmful upper end. An effective response to get out of harm's way is overdue.

1. Introduction

Two of the consensus statements agreed upon by the participants of an international scientific workshop on climate change and disaster losses in 2006 read:

- Climate change [of any kind] and [natural climate] variability are factors which influence trends in disasters.
- There is evidence that changing patterns of extreme events are drivers of recent increases in global losses.[4]

Hence the global insurance industry has already been feeling the impacts of a changing climate for many years and certainly will feel these impacts under continued anthropogenic climate change over the coming decades.[5] This chapter will provide an overview of the science of anthropogenic climate change, including an introduction to the fundamental concepts, terms, definitions, observations and model projections of future climate.

2. Weather, climate and climate change

2.1 Weather and climate

The term *weather* describes a combination of short-term meteorological conditions such as temperature, precipitation, pressure, wind speed and wind direction occurring at a particular time and place. By contrast, one might be interested in a long-term summary of weather conditions at a specific place over a given period (e.g. a specific month or season) that describes both the average conditions and the variability of these conditions. This concept is called *climate*—the long-term statistic of weather—and comprises the properties of the distributions associated with various meteorological parameters such as the mean and the higher/lower percentiles pertaining to rare and extreme conditions. The term *climatic variability* denotes the deviations of climate statistics over a given period of time from long-term climate statistics relating to the corresponding calendar period. Included in this variability are changes in extremes, but also more gentle fluctuations from year to year or from decade to decade. The complex and interwoven physical system including the atmosphere, the hydrosphere, the domain of snow and ice (cryosphere), the land surface and the biosphere is called *the global climate system*.

2.2 Internal and external climate variability

Part of the climate variability is the so-called *internal variability* of the climate system (i.e. climate variability that is not forced by external agents such as greenhouse gases, aerosols or solar variability). Internal climate variability occurs on all timescales, from weeks to centuries and longer, and is driven by stochastic atmospheric fluctuations modified by the oceans or other compartments of the climate system. Slow climate components, such as the ocean, play particularly important roles on decadal and century timescales because they integrate weather variability, enhancing the low-frequency

[4] Höppe and Pielke (2006). See also United States GAO (2007), Appendix IV, 56f.

[5] See United States GAO (2007), 8: "*The key scientific assessments ... found that warmer temperatures are expected to alter the frequency or severity of damaging weather-related events, such as flooding or drought, although the timing, magnitude, and duration of these changes are as yet undetermined. ... Research suggests that the potential effects of climate change on damaging weather-related events could be significant.*"

fluctuations. Thus, the climate is capable of producing long timescale variations of considerable magnitude without external influences. Internal climate variability encompasses oscillating features such as the *El Niño* Southern Oscillation (ENSO) affecting foremost the tropical Pacific region, the North Atlantic Oscillation (NAO) affecting foremost the eastern North Atlantic region and the European winter storm climate, the Atlantic Multidecadal Oscillation (AMO) affecting large parts of the North Atlantic region and the activity of Atlantic hurricanes, the Madden-Julian Oscillation (MJO), the Pacific Decadal Oscillation (PDO) and many others.

By contrast, there are also changes in the climate system that are caused by agents external to the climate systems, for instance strong volcanic eruptions resulting in a few years of extraordinarily cool climate conditions brought about by particulate emissions to the stratosphere. Another example is a change in the atmospheric concentration of greenhouse gases (GHG) and aerosols through the burning of fossil fuels and in land surface properties through human activity—which we term *(anthropogenic) climate change* throughout the following report.[6]

In the past, the Earth's climate has varied greatly in terms of large amplitudes and various timescales, for instance over the quaternary glaciations and deglaciation cycles. There is strong evidence that these ice-age/warm-age alterations of nearly the last three million years are linked to regular variations in the Earth's orbit around the Sun, the so-called *Milankovitch cycles*.[7] These swings in orbital parameters result in changes in solar energy received in the northern continents, which are the primeval cause of the ice-age/warm-age climatic alterations on timescales measuring several tens of thousands of years. The atmosphere's CO_2 concentration, like the Earth's carbon cycle as a whole, responds to the subsequent change in global temperature, and amplifies the warming.

2.3 Anthropogenic climate change

By contrast, with anthropogenic climate change, the climatic change occurs on a timescale of decades and centuries, with no orbital forcing on global temperature. Instead, the activities of an industrial civilisation have been directly altering the abundance of GHGs and aerosols in the atmosphere through the burning of fossil fuels and have additionally been altering the land surface properties, both of which lead to a change in the energy balance of the Earth's climate system. Hence, in the case of anthropogenic climate change, it is not the changing global temperature which is the first and independent cause of atmospheric CO_2 concentration adjustments. Rather, the increase in the atmospheric CO_2 concentration driven by human activity and land-use changes is the primeval cause of adjustments in global temperature (i.e. warming).

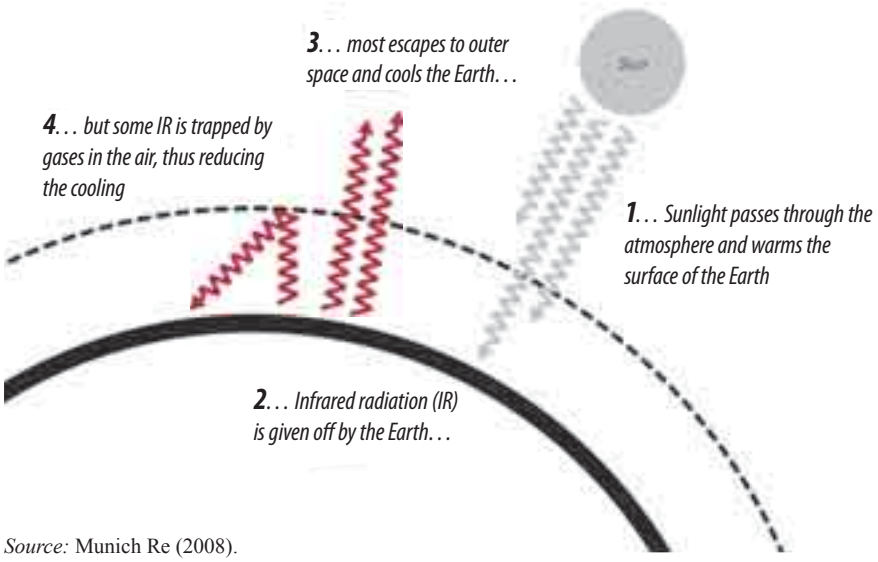
CO_2 is the most prominent of the so-called greenhouse gases which also comprise CH_4, N_2O, halocarbons and others—all of which have progressively increased in atmospheric concentration since the pre-industrial era. The temperature effect is due to the ability of the atmospheric GHG molecules to let the sun's incoming shortwave radiation pass through, whilst absorbing long-wave radiation emitted from the Earth's surface, directing part of this energy back to the surface, thus trapping heat within the

[6] United Nations (1992), Art. 1: "*Climate change means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods*."

[7] IPCC (2007), Ch.6: Palaeoclimate, 444ff.

surface-troposphere system. This mechanism is the so-called *greenhouse effect* and occurs naturally: without this mechanism, the Earth's average surface temperature of 14°C (57°F) could be as low as -18°C (-0.4°F) (Figure 1).

Figure 1: Schematic of the greenhouse effect.



Source: Munich Re (2008).

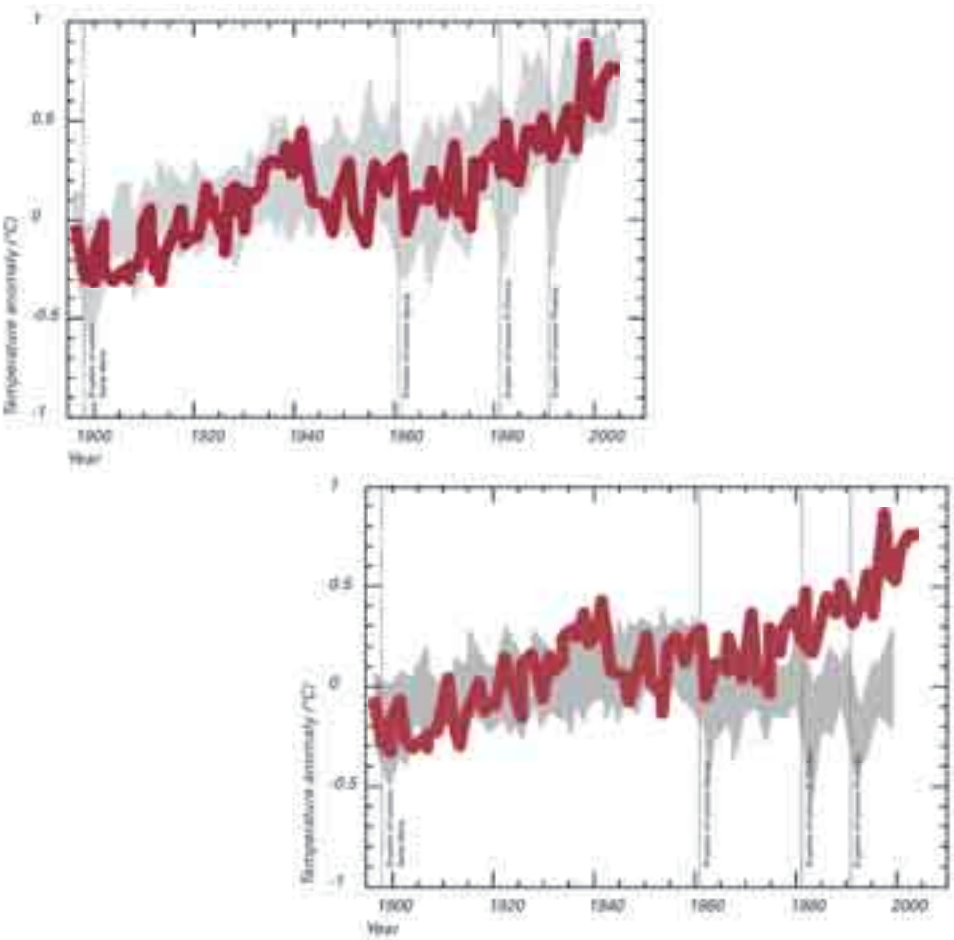
Anthropogenic climate change due to human-produced GHG emissions and land-use changes act to cause an enhanced greenhouse effect. The linear global warmer trend observed over the 100-year period 1906–2005 is 0.74°C [± 0.18°C] and we know that "*most of the observed increase in globally averaged temperatures since the mid-20th century is* very likely *due to the observed increase in anthropogenic greenhouse gas concentrations*"[8] (see Figure 2).

As the climate system has always been characterised by natural fluctuations and extreme conditions on a global and regional scale, it is impossible to attribute any single extreme event such as a strong tropical or extra-tropical storm to natural or anthropogenic climate change. A changing climate can only be detected by analysing meteorological parameters over many decades for trends in the parameters' mean and/or variability.[9] Causes of detected trends must then be established by arguments based on statistical and conceptual physical attribution methodologies (including also numerical model procedures). Once a trend or a fraction of a trend—e.g. for extreme precipitation events in a monsoonal climate—has been attributed to anthropogenic climate change, climate change can be identified as a driver for an associated enhanced level of risk, which in the long term would translate in an enhanced level of losses.

[8] IPCC (2007), Summary for Policymakers, 10.

[9] *Ibid*. Annex I: Glossary, 943: "*a change in the state of the climate that can be identified ... by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer*."

Figure 2: Observed versus model-simulated global mean temperature over the 20th century.



Left: red curve indicates observation; grey corridor represents climate model runs using the drivers "volcanism" and "solar irradiation" (i.e. all the natural drivers) and the driver "anthropogenic greenhouse gas concentrations". The climate models accurately match the temperature development observed and in particular reflect very well the strong increase over the last third of the period. Right: red curve is same as left; grey corridor represents climate model runs using only natural drivers (no anthropogenic forcings). The mismatch between models and observation becomes substantial since the 1960s.

Source: Munich Re (2008), after IPCC (2007) .

All of this information on climate science is based on the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR4) published in 2007. The IPCC was set up jointly by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) to periodically assess causes, impacts and possible response strategies to climate change. The latest report was prepared by three

working groups involving many hundreds of international experts. It serves as a reference for the political response process which is represented by the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. Besides the IPCC report, we also include other peer-reviewed studies in this chapter, in cases where scientific progress has been made since 2007. Table 3 lists common arguments of climate change contrarians and the related scientific evidence based on the IPCC findings.

Table 3: Common arguments of climate change contrarians and scientific evidence

Argument	Disproving scientific evidence
CO_2 does not match the temperature record over the 20th century.	The 1940-70 cooling is readily explained in climate models as largely caused by sulphate aerosols.
Temperature leads CO_2 by 800 years at glacial terminations recorded in ice cores.	The glacial-to-interglacial change in global climate does not tell us anything about recent global warming. In the Ice Age case, CO_2 does not initiate the warmings, but acts as an amplifier once they are underway.
Solar activity can explain the temperature trend since the industrial revolution.	Solar activity has not increased since the 1950s and therefore is unlikely to explain the recent warming. Solar forcing since the industrial revolution is only 1/13th of total net anthropogenic climate forcing over this period.
Global average temperature today is not as high as it was during other times in recent history, such as the Medieval Warm Period.	Regionally, there may have been places that did exhibit notable warmth but all the global reconstructions agree that it is warmer now and temperature is rising faster than at any time at least in the last 1,000 years.
Global warming stopped in 1998.	1998 was elevated above the existing trend line by the strongest *El Niño* of the century. Including 1998, 2001-2006 are the six warmest years on record.

3. What has been observed so far

3.1 Temperature and precipitation

As is evident from observations of near-ground air temperatures and sea surface temperatures, the warming of the climate system is unequivocal and the linear warming trend over the last 50 years [0.13°C/decade] is nearly twice that for the last 100 years [0.074°C/decade]. Thus the warming has accelerated.[10] Furthermore, the heat content of the upper oceans has also demonstrated a warming trend.[11] Consistent with global warming are widespread observations of large reductions in the numbers of cold nights and frost days, while hot days and hot nights have become more frequent. Heatwaves have increased in duration and frequency in many regions over the latter half of the 20th

[10] IPCC (2007), Technical Summary, 36.
[11] *Ibid.,* Technical Summary, 47f.

century; in particular, the subtropical regions are becoming hotter and dryer. Very dry land areas across the globe have more than doubled since the 1970s and drought has increased in the Sahel, southern Africa, parts of southern Asia, the south-western United States, Australia, the Mediterranean region and the Amazon.[12]

Long-term trends from 1900 to 2005 have been observed in precipitation over many large-scale regions, including eastern parts of North and South America, northern Europe and northern and Central Asia.[13] Over Europe, a stronger winter NAO in the 1990s led to wetter and stormier conditions in Northern Europe and drier conditions over the Mediterranean regions. The frequency of heavy precipitation events has increased over most land areas, consistent with warming and observed increases of atmospheric water vapour due to the higher water-holding capacity of a warmer atmosphere. For large parts of North America, Europe and Asia, there is evidence that the relative increase in precipitation extremes is larger than the increase in mean precipitation, as demonstrated by a higher contribution of heavy rainfall events to total annual rainfall.[14] Monsoonal climates have also experienced substantial changes: in the Indian summer monsoon, heavy precipitation events have increased strongly over the last decades, which is consistent with the warming of the Indian ocean's surface waters.[15]

3.2 Ice, snow and sea level

In the sphere of ice and snow, the cryosphere, we have observed a decrease of northern hemisphere snow cover since the late 1960s, in particular in spring, with a stepwise drop of 5 per cent in the late 1980s. Also widespread decreases in snowpack have been documented from mountainous regions; permafrost and seasonally frozen ground is shrinking. The maximum area covered by seasonally frozen ground decreased by about 7 per cent in the Northern Hemisphere over the latter half of the 20th century, in spring by 15 per cent in some places.[16] Annual summer minimum Arctic Sea ice extent has shrunk by about 7.4 per cent [± 2.4 per cent] per decade since the late 1970s[17] and in 2008 both the north-eastern and north-western polar ship routes were navigable without icebreakers for the first time. Glaciers and ice caps have experienced widespread mass losses—in the European Alps two-thirds of the glaciers' volume has disappeared since 1850[18]—and contributed to sea level rise. In particular "*the late 20th century glacier wastage* likely *has been a response to post-1970 warming*."[19] Recent observations show substantial accelerations in *ice flows* such as in some Greenland outlet glaciers and West Antarctic ice streams, which could substantially increase the contribution from the ice sheets to sea level rise (SLR).

Global SLR appears to have accelerated from on average 1.7 mm/year over the entire 20th century, to 3.1 mm/year over the past 15 years alone. Over the period from 1993 to 2006, approximately half the global average SLR is accounted for by thermal expansion, one quarter by the melting of glaciers and ice caps, and approximately 1/8 by the melting

[12] Trenberth (2008).
[13] IPCC (2007), Summary for Policymakers, 7.
[14] Alexander *et al.* (2006), Fig. 6 (b); IPCC (2007), Ch. 3, 302f.
[15] Goswami *et al.*(2006), 1442-1445.
[16] IPCC (2007), Technical Summary, 43.
[17] *Ibid.,* Technical Summary, 44.
[18] EEA (2008), Report 4/2008, 5.3, 60ff.
[19] IPCC (2007), Technical Summary, 44.

of the Greenland and West Antarctic ice sheets. It is believed that the contribution from the latter could be higher over the coming decades.[20]

3.4 Storm phenomena

Observations show an increase in intense *tropical cyclone activity* in the North Atlantic since about 1970. An increase in tropical cyclone frequency has also been observed since the mid-1990s, after a calm period from 1970 to the early 1990s. This activity change coincides with an upswing in the so-called *Atlantic Multidecadal Oscillation* (AMO) from a cold phase to a warm phase. A warm phase of the AMO results in warmer sea surface temperatures (SST) and on average reduced vertical wind shear in the tropical main development region of Atlantic tropical cyclones. The issue of attribution of this trend in activity (i.e. anthropogenic climate change, the AMO or both of these causes) is still under debate; the IPCC AR4 states that "*most of the warming since the 1970s can be associated with global SST increases rather than the AMO*".[21] Most hurricane experts believe that in reality both factors are likely to have played a role.

A change in the geography of Atlantic hurricanes has also been observed: in March 2004, the first and only documented hurricane in the South Atlantic which caused damage on land (Santa Catarina, Brazil) occurred, and in the record season 2005 tropical storm Delta reached the Canary islands and Hurricane Vince attained hurricane strength near Madeira, eventually making landfall in Europe as a weak depression.

In the western North Pacific, studies show that typhoons have become more intense, with almost a doubling of the power dissipated annually since the 1950s and an increase of 30 per cent in the number of category 4 and 5 storms from 1990 to 2004 compared with 1975 to 1989.[22] Besides long-term changes, all basins with tropical cyclone activity show a substantial modulation of storm formation and development through *El Niño* and *La Niña* events.

For extra tropical winter storms in the northern and southern hemispheres, increasing trends in storm frequency and intensity have dominated in recent decades. In particular, the North Atlantic storm track has shifted about 200 km northward in winter during the past half century, with storm intensity increasing over the North Pacific and North Atlantic. Again, northern storminess slightly declined after the maximum around 1990, consistent with the change in level of the NAO index.[23]

Observational evidence for changes in small-scale severe weather phenomena (such as tornadoes, hail and thunderstorms) is mostly local and too scattered to draw general conclusions; increases are observed in many areas due to increased public awareness and improved data collection. Significant severe thunderstorm conditions seem to have increased in frequency in some regions over the last decades. In the U.S. east of the Rockies, an increase has been observed in the number of annual six-hourly atmospheric conditions supportive of significant severe thunderstorms following a minimum in the mid-1970s, and also the number of annual reports of extreme hail (> 7 cm in diameter) has increased strongly since then.[24] Reports from Switzerland and south-western Germany

[20] IPCC (2007), Technical Summary, 48-51; EEA (2008), 5.4.2, 78-81.
[21] IPCC (2007), Ch. 3, 304ff (306). See also for instance, Goldenberg *et al.* (2001); Trenberth and Shea (2006); Zhang and Delworth (2006); Wang *et al.* (2008).
[22] Emanuel (2005a and 2005b); Webster *et al.* (2005).
[23] IPCC (2007), Ch. 3, 280-285, 312-313.
[24] Brooks and Dotzek (2008), 32-52.

indicate increases in significant severe thunderstorm environments in recent years.[25] For tornado activity it is likely that the increases in reports in the U.S. and in Europe in the latter half of the 20th century is due to enhanced detection and reporting efficiency and not to physical changes in tornado occurrences.[26]

4. Projections of future climate change from a regional perspective

4.1 Likelihood of future trends and model uncertainty

Table 4: Probability assessment of recent trends, human influence on trends, and future trends[27]

Phenomenon and direction of trend	Likelihood that trend occurred in late 20th century (typically post-1969)	Likelihood of a human contribution to observed trend	Likelihood of future trend based on projections for 21st century*
Warmer and fewer cold days and nights over most land areas	Very likely (probability > 90%)	Likely (probability > 66%)	Virtually certain (probability > 99%)
Warmer and more frequent hot days and nights over most land areas	Very likely (probability > 90%)	Likely (nights) (probability > 66%)	Virtually certain (probability > 99%)
Warm spells/ heatwaves: frequency increases over most land areas	Likely (probability > 66%)	More likely than not (probability > 50%)	Very likely (probability > 90%)
Heavy precipitation events: frequency (or proportion of total rainfall from heavy falls) increases over most areas	Likely (probability > 66%)	More likely than not (probability > 50%)	Very likely (probability > 90%)
Area affected by droughts increases	Likely in many regions since 1970s (probability > 66%)	More likely than not (probability > 50%)	Likely (probability > 66%)
Increased incidence of extreme high sea level (excludes tsunamis)	Likely (probability > 66%)	More likely than not (probability > 50%)	Likely (probability > 66%)
Intense tropical cyclone activity increases	Likely in some regions since 1970s (probability > 66%)	More likely than not (probability > 50%)	Likely (probability > 66%)

** using IPCC Special Report on Emissions Scenarios (SRES) scenario.*

[25] Schiesser (2003), 65-68; Potsdam Institute for Climate Impact Research (2005).
[26] IPCC (2007), Ch.3, 316.
[27] *Ibid*., Technical Summary, 52.

Most of the trends which have been observed so far are projected to continue and in some cases become stronger under future climate change. The IPCC developed four principal emission scenario families in order to prescribe possible future worldwide socio-economic development and associated emissions as a boundary condition for global climate model runs.[28] According to the IPCC, the following trends will continue under anthropogenic climate change (Table 4).

At this point it is important to consider that uncertainties are inevitably involved at all stages of the climate modelling process. For instance, uncertainty is involved in the representation of both Earth system processes and internal climate variability in models. Both items can be controlled by specially designed experiments.[29] Further on, there might be some sort of tipping behaviour in some elements of the climate system itself which puts reliable projections beyond the models' achievable accuracy. For instance, climate model projections differ substantially about the future state of the *El Niño*-Southern Oscillation regime in a warmer world. Some project a shift toward more persistent or frequent *El Niño* conditions, others simulate an increased amplitude of *El Niño* events with no substantial change in frequency.[30]

4.2 Cryosphere, sea level, extra tropical winter storms and severe weather

In addition to the above trend projections, the following phenomena deserve particular attention under anthropogenic climate change:

- Even if the concentrations of greenhouse gases and aerosols were held fixed at the values of the year 2000, the climate system would continue to respond, resulting in a warming trend of 0.1°C per decade over the next two decades. This so-called *committed climate change* is due foremost to the strong coupling of atmospheric processes to the oceans and their thermal inertia associated with long timescales for adjustment.[31]
- Cryospheric changes will continue and even accelerate in the direction already observed (see above). In particular, the extent of summer Arctic Sea ice is shrinking much faster than modelled and a summertime Arctic free of ice could be reality before the end of the 21st century, implying substantial changes to northern ship routes, exploration of oil and gas and fisheries. The European Alps could lose 80 per cent of their ice cover averaged over 1971-1990 if temperatures rose by 3°C,[32] implying dramatic changes to river flow and agricultural regimes as well as to tourism. Thawing permafrost ground will destabilise railway and road embankments, pipelines, avalanche defences, buildings and pylons of the electricity grid.
- Since the dynamic mechanisms behind the recently observed accelerated ice flows in Greenland and the west Antarctic are not captured by the current IPCC

[28] For instance, the IPCC SRES A1B scenario implies a future world of rapid economic growth, a global population which peaks in mid-century and a rapid introduction of new and more efficient technologies. Regional differences are decreasing and the energy system is characterised by a balance across all sources.
[29] IPCC (2007), Ch.10, 797-800.
[30] Lenton *et al.*(2008).
[31] IPCC (2007), Technical Summary, 68.
[32] EEA (2008), 5.3, 63.

models, the IPCC projections of SLR are likely to underestimate future SLR.[33] Against the IPCC AR4 range of 18-59 cm of global average SLR by 2090-99 (above the 1980-99 level), there are more recent studies indicating the possibility of much higher global average sea levels by the end of the 21st century. For example, ranges of 50-140 cm or 80-200 cm SLR by the end of the 21st century were arrived at by using different approaches.[34] The key implication of these scientific SLR estimations exceeding the IPCC AR4 range is that there might be a substantial increase in future exposure to coastal flooding that will urge settlements in low-lying coastal areas and established sea ports near river deltas to retreat from the coast or at least to dramatically adjust coastal protection measures.

- For extra tropical winter storms in a future warmer climate, models show a tendency for a poleward shift of storm tracks by a few degrees in both hemispheres, with greater activity at higher latitudes.[35] Some climate model ensemble studies demonstrate substantial increases in storminess by the end of the 21st century leading to heavily increased loss ratios, under the assumption of buildings not adjusted to a changing storm climate. There could be less frequent but more intense winter storms over Europe in a warmer climate.[36]
- Significant severe thunderstorm environments are likely to increase in some regions of a warmer world, as was recently shown by a climate model study for the U.S.[37]

4.3 Changes in regions

In a regionalised perspective, one might identify the following challenges[38] and—to a lesser degree—also opportunities:

- *Africa* is particularly vulnerable to climate change on account of low societal adaptive capacities. In particular, drought is prominent in the Sahel and Southern Africa; by 2020 agricultural yields could be reduced substantially in some African countries. Low-lying regions will also be exposed to increased risk of coastal flooding, along with coastal erosion and aquifer salinisation due to SLR.
- In *Asia* climate change comes on top of various socio-economic pressures on natural resources such as rapid urbanisation, industrialisation and economic development. In the coastal delta regions, which are densely populated, flooding from SLR and rivers will become more and more a focal issue, as will the availability of fresh water in populated areas. Drought will increasingly be an issue in south-western, southern and south-eastern Asia and in parts of

[33] IPCC (2007), Technical Summary, 45; EEA (2008), 5.4.2, 78ff and Box 5.6.

[34] Rahmstorf (2006) arrived at 50-140 cm. While this approach extrapolates the correlation of global mean surface temperature and historically observed global SLR for future global warming scenarios, the assumption of linearity between temperature and sea level is strongly debated in scientific discussions. Pfeffer *et al.* (2008) arrived at 80 cm up to 200 cm at maximum accounting for future limits on dynamic ice sheet loss from Greenland and West Antarctica.

[35] IPCC (2007), Ch. 10, 789.

[36] Leckebusch and Ulbrich (2004), 181–193; Leckebusch *et al.*(2007); Pinto *et al.* (2007); Schwierz *et al.* (2008).

[37] Trapp *et al.*(2009), see also Trapp *et al.* (2007).

[38] See for the regions listed below IPCC (2007), WGII and also ISDR (2008), 3-4.

East Asia. Food security will become an issue due to high pressures on crop productivity.

- *Australia/New Zealand* will suffer from more frequent heatwaves, droughts, fires, floods but also more frequent storms and coastal flooding. Water supply for cities and agriculture will become a major issue in West, South and also south-east (Murray-Darling basin) Australia.
- *Europe* will likely face reduced rainfall, more heatwaves, droughts and wildfires in the southern parts. In northern Europe, winter precipitation and floods will increase along with summer flash floods and hot spells. More intense winter storms will push up loss amounts and, compounded with SLR storm surges, will challenge low-lying coastal areas. North of the Mediterranean, a prolonged thermal vegetation period, milder winters and warmer summers will also open up chances in agriculture and tourism.
- In *Latin America*, changing precipitation patterns and the shrinking of glaciers and ice caps will significantly reduce the amount of water available for urban consumption, agriculture and hydropower. Food security will decrease due to lower crop and livestock productivity. SLR will be an issue for low-lying coastal areas. In the Caribbean, more intense tropical cyclones could pose a severe threat.
- *North America*'s coasts could suffer from more intense tropical storms, mountain snowpack in the Southwest and water supply will shrink, winter flooding will increase and summer flows be reduced. More frequent and longer heatwaves, drought conditions in particular in the Southwest and consequent wildfires will show up.
- *Small island states* will be affected by floods, storm surges, coastal erosion and aquifer salinisation due to SLR and by reduced fresh water resources in the course of the 21st century.

4.4 Tipping points

Some of the future features of the climate system will evolve further if and when they pass so-called *tipping points*.[39] The tipping points describe elements of the climate system where there is a threshold behaviour beyond which the system can flip and go into another state by only a small perturbation. Hence, these changes are non-linear and could be even abrupt in character. From a societal-ethical perspective, consequent actions are needed to avoid such tipping points either in terms of early-warning systems to detect the proximity of some tipping points or in terms of binding political targets (e.g. the global warming tolerated at maximum 2°C above the pre-industrial levels from the EU perspective) aimed at the avoidance of these critical thresholds. An example of a tipping point is the threshold temperature for net ice mass loss of the Greenland Ice Sheet which might be in the order of +3°C local warming above pre-industrial level. Passing the threshold can start a process leading to a SLR of up to 7 metres in the course of hundreds of years. Further examples of tipping elements are the possible collapse of the West Antarctic Ice Sheet, which has a potential of 5 metres global SLR, or a change in the Atlantic convection (thermohaline circulation) which might imply a shutdown or

[39] Lenton *et al.* (2008), 1786-1793.

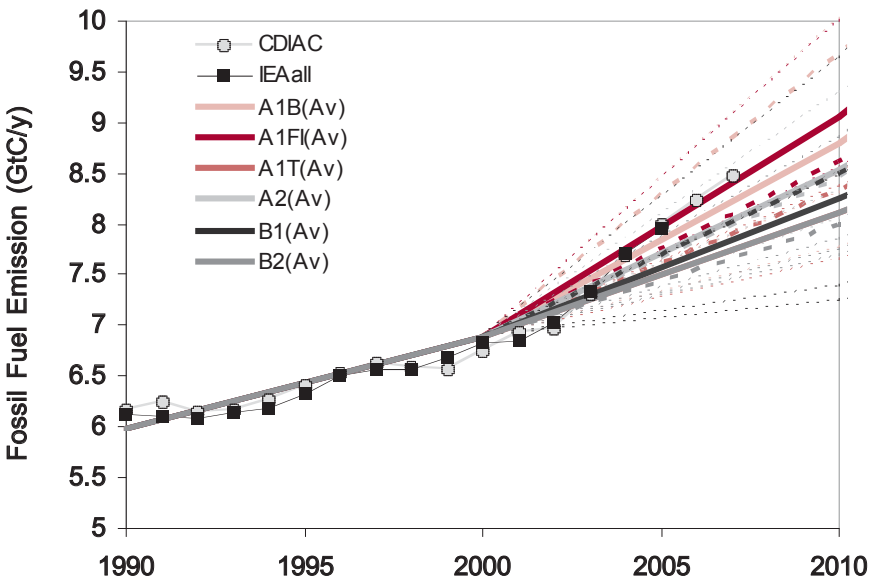
at least a slowdown of the Atlantic meridional overturning circulation and its alleviating effect for winter time Europe through the heat released from the Gulf Stream.[40]

A key factor in establishing the criticality of such physical tipping points as described above is determining the natural timescales of return to the original state, or whether there may be a point of "no return". The collapse of Arctic Sea ice, for instance, could conceivably be reversed after only a decade or so in a "cooling world". The key point of "no return" is thought to be the melting of the Greenland and the West Antarctic ice sheets. If loss of either of these ice sheets occurred, it is unlikely that they would grow back within any reasonable human timescale.

4.5 Today's excessive CO_2 emissions—a matter of urgency

In recent years the actual global CO_2 emissions have begun tracking close to (and even slightly above) the most intense fossil fuel scenario established by the IPCC's range of scenarios, the so-called *A1-Fossil-Intense scenario*. This means that current reality is exactly at the level which IPCC perceived as the carbon intense upper end a few years ago (Figure 3).

Figure 3: Fossil fuel emissions



Solid curves: representing IPCC SRES scenarios (dashed lines for uncertainty ranges). Filled squares: representing observations according to CDIAC (U.S. Department of Energy Carbon Dioxide Information and Analysis Center).
Open circles: representing observations according to IEA (International Energy Agency).

Source: Canadell *et al. (2008).*

[40] Other tipping elements are a future state-transition in the *El Niño*–Southern Oscillation regime, in the Indian summer monsoon, in the West African monsoon, in the Amazon rainforest and in the Boreal forest. See Lenton *et al.* (2008), 1786-1793, for discussion.

On the current pathway the Earth's civilization is moving away from the target of stabilizing the atmospheric CO_{2eq} concentration at 450-550 ppm, which is expected to limit global warming to around 2°C above the pre-industrial level. This underscores the urgency not only of mitigating GHG emissions, but also of adaptation to the inevitable impacts. In both fields the insurance industry can play an active role.

Chapter 3
Impacts of climate change on the world economy in a "business as usual" scenario

Benedikt Rauch and Michael Menhart

Climate change—who will pay the bill?

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The long-term challenges of climate change can only be met by starting today.

***Mr Andrew Moss**,*
Group Chief Executive, Aviva, U.K.

Key message

Unmitigated climate change is likely to have significant adverse effects on the long-term development of the world economy.

1. Introduction

This chapter analyses the potential economic and societal consequences of climate change in a "business as usual" scenario. This implies a failure to significantly reduce emissions of greenhouse gases, which could lead to rises in global average temperatures of up to 6.4°C by 2100.[41] As a starting point, we want to explore in general terms how unmitigated climate change will affect people around the world, using evidence presented in the Stern Review and the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR4). This is followed by an analysis of the economic consequences of weather-related natural catastrophes, which are expected to increase in frequency and intensity due to global warming. Finally, we will look at the overall impact of unmitigated climate change for the world economy, illustrated by simulated impacts of gradual climate change and simulations of abrupt changes in climatic conditions. Economic consequences are analysed for both developed and developing economies, thus considering differences in adaptive capacities. We conclude that unmitigated climate change is likely to have significant adverse effects on the long-term development of the world economy.

2. Climate change impacts on physical, biological and human systems

Global warming will be accompanied by many climatic changes, in particular changes to the water cycle and sea levels, which will affect water availability, food production, ecosystems and human health.

2.1 Water

Water resources and management capacities are at the heart of economic growth and development. Globally, about 70 per cent of all freshwater supply is used for irrigation and food production, 22 per cent for manufacturing and energy, and 8 per cent by households and firms for drinking and sanitation.[42] Currently, around one-third of the world's population is estimated to live in water-stressed countries.[43] By 2030, global water demand is predicted to rise 25-30 per cent due to population growth, urbanisation, increasing economic affluence and changes in consumption patterns. As global warming is expected to influence the regional distribution of freshwater as well as the year-to-year and seasonal variability of precipitation, the stresses on freshwater systems resulting from socio-economic developments will very likely be aggravated by climate change in several regions of the world. The Food and Agriculture Organization of the United Nations (FAO) projects that two-thirds of the world's population could be living under water stress conditions by 2025.[44]

- The Stern Review warns that unmitigated climate change will have serious consequences for people who depend on glaciers or mountain snowmelt to maintain water supplies during summer. Currently, more than one-sixth of the world's population lives in regions supplied by melt water from major mountain

[41] IPCC (2007b), Technical summary.
[42] Unesco (2006).
[43] Stern (2007a).
[44] FAO (2007).

ranges, such as the Himalayas, the Andes, the Rocky Mountains or the Alps. While water flows may initially increase in winter and spring, as the snow melts more rapidly, run-off will be reduced in summer and autumn, when additional supplies are most needed. In the long run, dry-season water flows will disappear permanently, once the glaciers have completely melted.

- In the subtropical regions, where further decreases of water availability are projected, higher water temperatures and lower river run-offs could force power plants (hydropower as well as coal-fired or nuclear, which often rely on large volumes of water for cooling) to throttle production. Other industrial sectors exposed to scarcity of reliable and clean water include semiconductor manufacturing, metals and mining, biotechnology and pharmaceuticals, food and beverages, and textiles.
- Warmer water and lower water flows could also degrade the quality of drinking water, exacerbate many forms of water pollution and enhance health risks.

The IPCC AR4 suggested that by 2050, river run-off could decrease by 10-30 per cent over some dry regions of the mid-latitudes and in the dry tropics.[45] Dry areas particularly exposed to climate change impacts include the Mediterranean basin, the western United States, southern Africa and north-eastern Brazil. On the other hand, water availability in regions at high latitudes or in the wet tropics is expected to increase due to climate change. However, IPCC scientists emphasize that from a global and holistic perspective, the negative impacts of future climate change on freshwater systems are likely to outweigh the benefits.[46] Firstly, by the middle of the 21st century, the area of land subject to increasing water stress due to climate change is projected to be more than double the area with decreasing water stress. Secondly, in many regions which benefit from increased water supply, this benefit is likely to be counterbalanced by the negative effects of increased variability of precipitation, deteriorating water quality and growing flood risks in wet seasons.

2.2 Food productivity

Heat stress and water scarcity due to climate change could cause significant global declines in crop productivity. In some areas, such as the mid and high latitudes, crop productivity could initially increase (up to a 1-3°C global temperature increase), but could then decline as the world continues to warm. At lower latitudes, crop productivity could decline for even small increases in temperature.[47] For example, compared to a baseline without climate change, the expected loss of global cereal output in the case of 3°C global warming would be more than 10 per cent.[48] Such a constriction in the supply of food would have significant effects on the global economy, which are considered in section 3. The Stern Review showed that the reduction in crop productivity may put 250-550 million additional people at risk of hunger, compared to currently around 800 million people.[49]

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[45] IPCC (2007), Technical summary.

[46] Bates *et al.* (2008).

[47] IPCC (2007), Technical summary.

[48] Assuming mostly farm-level adaptation in developing countries and some economy-wide adaptation in developed countries (Stern, 2007a).

[49] These estimates do not take into account a range of possible climate change impacts which are likely to further reduce agricultural yields, such as the increased threat of pests and diseases.

2.3 Ecosystems

Climate change also puts pressure on ecosystems (e.g. forests, oceans, soil) and leads to biodiversity loss. Rises in global average temperature of around 2°C are expected to put 20-30 per cent of plant and animal species at increased risk of extinction, and in the case of 3°C global warming up to 50 per cent of land species could be facing extinction, including species essential for pollination.[50]

2.4 Health

A scientific survey of the literature on health impacts from climate change concludes that while the reduction in cold-related mortality may outweigh the increase of heat-related mortality for small rises in average temperature, higher increases are likely to increase mortality.[51] The impacts will also be regionally dependent, with the strongest negative impacts in lower latitude areas. The World Health Organization (WHO) estimates that climate change is already responsible for over 150,000 deaths annually through a rising incidence of diseases and malnutrition.[52] Unmitigated climate change is expected to negatively affect water quality and could thus increase the incidence of water-borne diseases (e.g. diarrhoea). In addition, higher temperatures could lead to a wider distribution of vectors for diseases such as malaria, dengue fever and West Nile fever. However, there is an ongoing scientific debate about the potential impact of climate change regarding the distribution of infectious diseases compared to the role of economic development and the associated better access to health care expected in this century, which could significantly reduce the vulnerability to diseases in many societies.[53]

2.5 Economic impacts of weather-related natural catastrophes

Some of the first and most severe impacts of climate change will come through its effects on the extremes of climate. Climate change can increase both frequency and intensity of extreme weather events such as storms, torrential rain, droughts and heatwaves.[54] For example, global warming is expected to lead to rising sea levels, which would heighten the risk of coastal flooding where no defensive measures are taken. According to the Stern Review, a 20-80 cm mean sea level rise caused by 3-4°C of warming is estimated to put between 7 and 300 million additional people at risk of being flooded each year.[55] This could be even higher if one considered the potential increase in storm surges. A recent report to the Organisation for Economic Co-operation and Development (OECD) estimates that, without adaptation, the population in the major 136 port cities around the world exposed to storm surges could increase from 40 million in 2005 to about 150 million in the 2070s, and the exposed assets are expected to rise from US$3,000bn to US$35,000bn.[56] The authors state that population growth, economic

[50] IPCC (2007), Summary for policy-makers, and Stern (2007a). Gallai *et al.*(2009) estimated the total economic value of pollination worldwide to amount to €153bn in 2005, which represented 9.5 per cent of the value of the world agricultural production used for human food that year.

[51] Hitz and Smith (2004).

[52] WHO (2003).

[53] Tol *et al.*(2006).

[54] IPCC (2007), Technical summary.

[55] The number of people at risk depends in part on different scenarios of population growth.

[56] Nicholls *et al.*(2008). Exposure to a 1-in-100-year coastal flood event assuming a sea-level rise of 50 cm on global average. Monetary amounts in "international 2001 U.S. dollars" using purchasing power parities.

growth and urbanisation are the most important drivers of this increase in exposure, and that climate change and subsidence significantly exacerbate their effect.

Estimates of economic or overall losses from natural disasters usually include direct physical damage, such as damage to cars, homes, infrastructure or crops, as well as indirect damage, such as loss of revenue or unemployment due to business interruptions, and market destabilization. The economic magnitude of natural catastrophes is often measured by comparing the economic losses caused by a disaster with the annual gross domestic product (GDP) of the affected country. For example, severe flooding in central Europe in August 2002 resulted in overall losses of about €16.8bn, which compares with approximately 0.7 per cent of the combined GDP of the countries mainly affected (Austria, the Czech Republic, Germany, Slovakia and Hungary) in 2002.[57] The 2003 heatwave in France caused losses for the agricultural sector alone amounting to about €4bn or 0.25 per cent of the country's GDP.[58] Estimates of overall losses—including also disruptions in power generation and transport and stress on forests—are in the dimension of €15bn, which is equivalent to 1 per cent of France's GDP in 2003.[59] Hurricane Katrina, which caused catastrophic flooding in New Orleans in 2005, killed more than 1,300 people and resulted in overall losses of about US$125bn.[60] In relation to the U.S. economy as a whole, the overall losses amounted to 1 per cent of GDP.

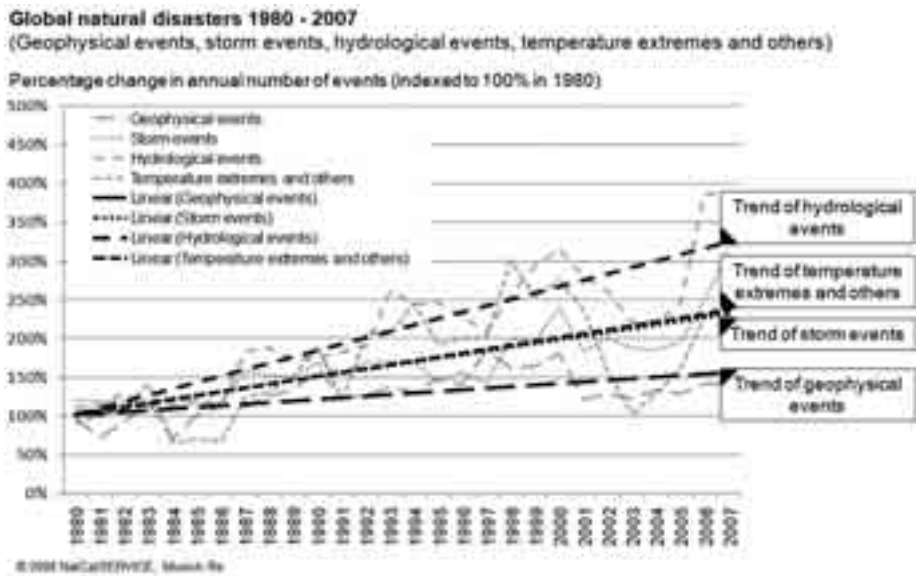
The relative size of economic losses from natural catastrophes varies with the degree of economic development of the country affected. From 1980 to 2004, total damage caused by windstorms and floods amounted to only 0.007 per cent of GDP in high-income countries, but 0.55 per cent of GDP in low-income countries.[61] A drought in Kenya in 1999, for example, caused damage amounting to 16 per cent of GDP, with 26 per cent of this due to hydropower losses and 58 per cent due to shortfalls in industrial production.[62] This may reflect the higher vulnerability of developing countries, arising mostly from geographical exposure or from lower economic diversification. Low-income economies tend to have a greater proportion of output which is sensitive to weather or climate. For example, whereas farming, forestry and fishing in India contributed 16.6 per cent to GDP in 2007 and employed about 60 per cent of the country's workforce, the agricultural sector accounted for only 1.2 per cent of GDP in the United States, employing 0.6 per cent of the U.S. labour force.

As regards economic growth, the net impact of natural disasters cannot be generalized as negative or positive. For example, on the one hand, the loss of productive capital might reduce economic activity, but at the same time, the replacement of damaged capital stock increases GDP. This effect is the result of GDP accounting, which does not consider losses to human or physical capital in themselves. Additional factors determining the effects of natural catastrophes on economic growth are size, wealth and flexibility of the affected economy. Large, wealthy and flexible economies tend to be resilient to local shocks of weather-related catastrophes, as for example the U.S. economy after Katrina in 2005. Smaller countries or poorer economies often lack this adaptive capacity and experience more negative impacts on economic growth. For example, for Ethiopia,

[57] Munich Re (2008).
[58] *Ibid*.
[59] EEA (2008).
[60] Munich Re (2008).
[61] Ramcharan (2007).
[62] The World Bank (2006).

an economic model incorporating historical hydrological variability has projected that extreme weather conditions may cut average annual GDP growth potential by up to 38 per cent (from about 2.8 per cent to 1.7 per cent per year) and increase poverty rates by 25 per cent.[63]

Figure 4: Increasing trend in annual number of hydrological events, storm events and temperature extremes



Source: Munich Re (2008).

A report from the United Nations Environment Programme's Finance Initiative (UNEP FI) estimated that losses from weather events are growing at an annual 6 per cent, thus doubling globally every 12 years.[64] Even though the observed increase in past losses is mainly caused by socio-economic factors (such as population growth, increased house building in vulnerable areas, increased wealth, increased amount and value of vulnerable infrastructure), there is evidence that an increase in the number of weather-related disasters is also a driver. For example, from 1980-2007, an increase in the worldwide number of storms, hydrological events (e.g. floods) and temperature extremes has been observed (Figure 4). Over the same time, there was only a relatively small increasing trend in geophysical disasters (e.g. earthquakes).[65] In order to determine the role of climate change as a driver of natural catastrophe losses, one has to adjust or "normalize" loss data for socio-economic changes. An evaluation of normalized losses from weather-related disasters since 1970 finds an upward trend of 2 per cent per year, indicating that climate change has already amplified the observable increase of total economic losses.[66] However, it should be noted that changes in climate include natural climate variations as well as

[63] The World Bank (2006).
[64] UNEP FI (2006).
[65] Munich Re (2008).
[66] Miller *et al.* (2008) analyse losses normalized for economic and population growth.

anthropogenic climate change. So, although it is likely that climate change has already contributed to increasing losses from weather-related catastrophes, it is still unclear what extent of this contribution can be attributed to anthropogenic global warming.[67]

3. Direct economic impacts of unmitigated climate change

The direct economic impacts of unmitigated climate change include the effects of gradually increasing average temperatures on physical, biological and human systems as well as effects from more frequent and more intense weather-related catastrophes and from potentially accelerating, large-scale changes in regional climates (e.g. strong weakening of the Gulf Stream). Indirect economic impacts of climate change—such as the consequences from regulatory or political responses to perceived climate change risks —will be explored in Chapter 4.

The Stern Review estimated the overall damage costs from unmitigated climate change as amounting to a loss of 5-14 per cent of global per capita GDP in 2200, compared to a baseline that assumes no change in climate. These cost estimates consider market impacts, non-market impacts (on human health and the environment) and the risk of abrupt, large-scale climate change. The size of the overall impact depends on the size of climate-system feedbacks and what estimates of non-market impacts are included. The underlying economic model assumes that 90 per cent of climate change impacts are adapted to in rich countries and 50 per cent in poor countries.[68]

A study by Morgan Stanley asserts that unmitigated climate change could drive the global economy into stagflation: stagnation of economic growth coupled with inflation.[69] According to the study, climate change is likely to reduce global output via its adverse impacts on the workforce (higher mortality, greater incidence of sickness) and the existing capital stock (physical damage from such phenomena as rising sea levels and more frequent and more intense storms). Thus, without sufficient adjustments in employment ratios or productivity, the potential for long-term economic growth is likely to be lower. Inflation pressure could arise due to a lower production potential or rising food prices (induced by either severe droughts or higher prices for ever scarcer freshwater in many regions). The authors suppose that the randomness of extreme weather events or conditions are likely to increase the volatility of the business cycle and make monetary or fiscal policy errors more difficult to avoid, which in turn could increase volatility. Hence, risk premiums are likely to increase and weigh on investment spending.[70]

Economic impacts of unmitigated climate change differ from region to region, not only because of geographical differences in speed and extent of climatic change but also due to regional differences in the ability to adapt to climate change impacts. Generally speaking, climate impacts are smaller and adaptive capacity is higher in developed countries than in less developed countries. The capacity to adapt to climate change impacts is greater in developed countries due to more diversified economies, more financial and

[67] Höppe and Pielke (2006).
[68] Stern (2007b).
[69] Bartsch (2007).
[70] Risk premiums are also expected to rise due to the uncertainty of the political response to climate change (see Chapter 4).

technological resources and better access to education and health care. Most industrialised economies are located in the temperate climate zones, where changes in temperature and precipitation patterns will be less pronounced than in, for example, the subtropics. Higher latitude regions could even benefit in the short term from moderate temperature rises of up to 2 or 3°C due to increased agricultural yields, a boost for tourism, lower winter mortality or lower heating requirements. However, most studies warn that negative effects of unmitigated climate change will prevail at higher temperatures. For instance, a simulation for the United States shows that reduced space heating costs could offset increased space cooling costs for some time. However, once temperature rises reach a critical level, simulated benefits begin to decline, eventually becoming losses.[71] Recent valuations of global warming impacts on agriculture in the United Kingdom expect improvements of yields in the 2020s, the beginning of a decline in productivity by 2050, and economic losses of up to £24m per year by the 2080s.[72]

A report prepared for the Pew Center describes the simulated potential climate change impacts on the U.S. economy.[73] The analysis is limited to market phenomena such as consumption and does neither take account of non-market considerations such as valuations of the environment or human health nor the risk of abrupt, large-scale climate change (all of which are considered in the cost estimations of the Stern Review cited above). The authors report that—under pessimistic assumptions regarding damage functions and adaptive capacity—climate change has the potential to lead to a real U.S. GDP as much as 3 per cent lower in 2100 relative to a baseline that assumes no change in climate. In contrast, under optimistic assumptions, real GDP in 2100 is up to 1 per cent higher than in the baseline scenario. But due to threshold effects in certain key sectors, these economic benefits simulated for the 21st century under optimistic assumptions are only temporary and economic damage is inevitable. Regarding the magnitude of potential benefits compared to potential damage of climate change, the authors remark that the economic losses estimated under pessimistic assumptions are generally larger than the temporary benefits gained under optimistic assumptions. This asymmetry becomes even more pronounced with rising temperatures as expected damage costs of extreme weather events increasingly offset potential gains in certain sectors of the economy.

The reliance on climate-sensitive sectors such as agriculture in most low-income economies reduces their generally lower adaptive capacity. Furthermore, due to their geographic exposure, many developing countries will be hit harder by climate change than most wealthy countries. For example, countries in the already hot and dry subtropics face higher temperatures and less precipitation.[74] The impacts of gradual changes in temperature and precipitation occurring over decades, and the increasing damage caused by extreme weather events, which global warming is expected to bring about, are a substantial threat for developing economies. Climate change is projected to exacerbate water scarcity and soil degradation. Especially in regions characterized by high population growth, high population density and poverty, this could lead to land-use conflicts and population movements, both within and between countries. A report by the Scientific Advisory Council to the German government expects that—in the event of mitigation efforts failing—climate induced social destabilization and security risks would manifest

[71] Jorgenson *et al.* (2004).
[72] EEA (2008).
[73] Jorgenson *et al.* (2004).
[74] IPCC (2007b).

themselves in various regions of the world from around 2025-2040.[75] Examples of hotspots include North Africa, where the densely populated Nile delta is threatened by sea level rise and salt water intrusion into agricultural land. In the Sahel, climate change is expected to put additional stress on fragile States such as Somalia, Chad or Sudan. The above-average warming in Central Asia will compound desertification and water scarcity in lakes and rivers shared between countries. While the coastal regions of South Asia and China are at risk from sea level rise, flooding and possibly more powerful tropical storms, the reduction in the flow of melting water from the Himalaya's glaciers could increase the potential for water conflicts.

Table 5: Summary of impact analyses of unmitigated climate change

Study/authors	Scope and impacts considered	Quantification of impact (compared to a baseline that assumes no climate change)
Stern Review's standard climate change scenario (mean warming of 3.9°C relative to pre-industrial in 2100)	Global market impacts and the risk of abrupt, large-scale climate change	Mean (and 90% confidence interval) loss in global per capita GDP of 0.2% in 2060, 0.9% (0.1-3%) in 2100 and 5.3% (0.6-13.4%) in 2200
Stern Review's high climate change scenario (standard scenario plus amplifying feedbacks)	Global market impacts, non-market impacts (on human health and the environment) and the risk of abrupt, large-scale climate change	Mean (and 90% confidence interval) loss in global per capita GDP of approximately 1% in 2060, 3% (1-9%) in 2100 and 14% (3-35%) in 2200
Jorgenson *et al.* for the Pew Center on Global Climate Change	Limited to market phenomena of gradual climate change in the United States	Under pessimistic assumptions, U.S. GDP could be up to 3% lower in 2100. Under optimistic assumptions, US GDP could be up to 1% higher in 2100.
IMF	Market impacts of an abrupt change in climatic conditions in a south Asian country	Immediate 2% contraction of GDP, widening to an 11% contraction over the ten years following the major climatic shock.

The consequences of climate change are likely to affect primarily the poorer sectors of the population such as subsistence farmers and people living in the slums of megacities. The report by the Advisory Council suggests that, in combination with social inequality and inadequate access to social services, climate change will increase the existing susceptibility—arising in part from ethnic and religious tensions—to violently expressed conflict.

[75] WBGU (2008).

In addition, scientists point out that once a certain tipping point is reached, the world is also at risk from abrupt and large-scale changes in regional climates, including scenarios such as a collapse or weakening of the Gulf Stream, significant damage to the Amazon rainforest or changes in weather patterns such as the monsoon rains in Asia or the *El Niño* phenomenon.[76] The likelihood of such events occurring is unknown, though the risks increase with global temperature rises.

In an economic model, the International Monetary Fund (IMF) examined the potential effect of changes in the monsoon pattern on a representative South Asian country which is heavily reliant on agriculture.[77] In this scenario, a sudden and permanent deterioration in climate leads to failed harvests and food shortages, which eventually result in higher mortality rates and emigration, reducing the population by a total of 2 per cent during the six years following the climate shock. In addition to this massive and rapid population decline, the model projects negative effects on the productivity of labour and capital. The drastic change in climate could make obsolete many existing agricultural businesses, respective distributional channels and associated industrial patterns. Many entrepreneurs might be forced to relocate or decommission existing capital stocks, and many workers might be compelled to migrate or retrain. Relative to a baseline without abrupt climate change, the negative productivity and population shocks cause an immediate 2 per cent contraction of GDP, widening to an 8 per cent contraction over the ten years following the major climatic shock. Assuming that financial markets react to the economy's deteriorating prospects by requiring a higher risk premium of 1 percentage point per year, the simulated negative effect on GDP expands to 11 per cent below the baseline. This reflects the growth-hampering effects of higher costs of capital and a reduction of capital accumulation.

4. Conclusion

The findings and hypotheses presented in this short overview of economic consequences of "business as usual" climate change can only reflect a part of the ongoing discussion. As always in economics, assumptions and projections can be controversially debated. Overall, we currently see strong support for the view that unmitigated climate change is likely to have significant adverse effects on the long-term development of the world economy. Higher latitudes regions could see some initial benefits, particularly in the health and food sectors, while other regions could see negative impacts for even small increases in temperature. Globally, the impacts of climate change are expected to become increasingly negative (perhaps exponentially) with rising global temperatures. Chapter 4 will elaborate on mitigation and adaptation options.

[76] Stern (2007a).
[77] IMF (2008).

Chapter 4
An overview of the response to climate change: mitigation and adaptation

Trevor Maynard, Rolf Tolle, Celine Herweijer, Benedikt Rauch and Michael Menhart

The potential contribution of the insurance industry towards supporting adaptation to and mitigation of climate change is greatly underestimated.

Dr Nikolaus von Bomhard,
Chairman of the Management Board, Munich Re Group, Germany

One of our specific commitments is our reaction to climate change, which is the largest risk shared in common by all human beings.

Mr Kunio Ishihara,
Chairman, Tokio Marine & Nichido Fire Insurance Company, Japan

Key messages

Adaptation and mitigation are the key actions available to contain the impact of climate change. They must be used in parallel and carefully designed to not conflict. Climate change is one of several major global trends including population growth, urbanisation and water shortage; responses to climate change must consider these other issues and avoid exacerbating them. Strong policy-maker incentives are required to drive the necessary change.

1. Mitigation

1.1 Mitigation targets

The United Nations Framework Convention on Climate Change, Article 2 states that "*The ultimate objective of this Convention and any related instruments that the Conference of the Parties may adopt is to achieve ... stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous interference with the climate system*." Weighing up the costs and benefits of mitigation is challenging due to the scientific and economic uncertainties involved. In the past few years, a number of studies have attempted this using different technical methods and have arrived at recommendations for global emissions cuts. From a cost perspective, the U.K.'s 2006 Stern Review suggested that dangerous climate change could be avoided by accepting a reduction of 1 per cent p.a. in GDP. Lord Stern has since revised this upwards to 2 per cent p.a.[78] because changes are proceeding at a faster rate than expected and some potential extreme outcomes have a higher probability than expected. In line with this, the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC AR4) reviewed all available evidence and suggested that the cost of mitigation will range from 0-4 per cent of GDP to stabilise at 550 ppm CO_2e (carbon dioxide and other "equivalent" gases).

Rather than mitigate climate change, the other option is to do nothing. The Stern Review estimated that the costs of inaction were far greater at 5-20 per cent of GDP. Some economists have criticised Stern's choice of discount rate and believe costs are lower; others believe that the costs are higher. Taking current climate models, economist Martin Weitzman has calculated that there is a 1 per cent chance that the temperature in 2200 will be 20 degrees higher than now. He argues that this would be so catastrophic for life on earth that normal cost benefit analyses lack robustness for setting climate policy. He believes that urgent action is required to mitigate these extreme risks. The climate has a considerable inertia (in other words stimuli to one part of the system take a long time to have full effect on the whole). This is both an opportunity and a risk. It is an opportunity because steps taken to reduce greenhouse gases in the short term will have a considerable positive impact in future and are therefore highly desirable and highly rewarded. The risk associated with inertia is that if we wait too long to take action the opportunity to steer the climate system away from dangerous levels of change may require much more costly intervention or have passed altogether.

The Stern Review suggested a target of 450-550 parts per million of CO_2e; Lord Stern now believes the upper limit should be at most 500 ppm. The recent report by the U.K.'s Committee on Climate Change agreed with this perspective and linked this with a requirement for a 50 per cent reduction in global emissions by 2050 (with an 80 per cent reduction for the U.K.). Jim Hansen, the well respected climate scientist, has argued for 350 ppm, others argue that these targets are so likely to fail that we should be realistic and aim for above 600 ppm and that we should incorporate "overshoots" into the target. However, while more achievable, such high targets leave risks to society that are unacceptably high. The EU's target of a 60-80 per cent reduction in greenhouse gas emissions by 2050[79] is a huge transformation; some have described this as twice the

[78] Jowit and Wintour (2008).

[79] Conclusions of the Spring European Union Council of 8 and 9 March 2007.

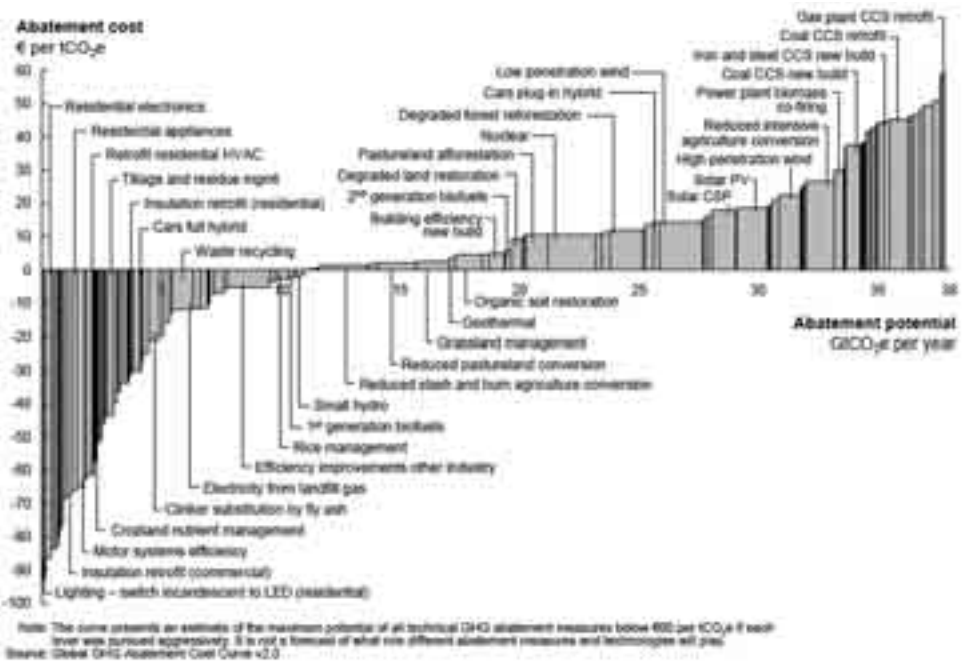
industrial revolution in a quarter of the time. Many are arguing that the current pace of change from governments and businesses does not match the enormity and urgency of the situation.

1.2 Methods for reducing greenhouse gas emissions

The global emissions cuts now called for by many governments will require a significant and rapid transition towards a low-carbon economy. Energy will need to be used more efficiently and generated more cleanly. The IPCC estimates that power supply accounts for around 21 per cent of global greenhouse gas emissions, and fossil fuel supply for another 5 per cent. These two approaches, energy efficiency and energy reduction, must go hand-in-hand. Achieving this will require more widespread use of clean technologies coupled with technology innovation. There is no silver bullet—mitigation will require a mix of technologies.

The McKinsey abatement curve (Figure 5) shows the cost or savings relating to various forms of mitigation. Where the columns are below zero it indicates that the mitigation option actually saves money in net present value terms (though there may be an initial capital outlay outweighed by savings later). Where the column is above the line the options have an associated cost. The total cost or saving of a given option is found by calculating the area of the column which gives the product of abatement potential (i.e. the volume of CO_2e saved) with the cost per unit volume.

Figure 5: Global greenhouse gas abatement cost curve



Source: McKinsey & Company (2009)

A summary of the main clean energy generation technologies is given below.

Solar energy

Energy from the sun is converted into electricity (mostly using photovoltaic methods currently) or heat (solar thermal). The photovoltaic industry is growing rapidly but still suffers from high costs; the solar thermal market is also growing rapidly and is seen as more cost effective at present. Analysts predict that solar energy could provide up to 20 per cent of energy needs by 2030.

Biomass and biofuels

Plants extract energy from the sun and can then be used to provide fuel or energy. There are many forms of this technology. Biodiesel can be made from rapeseed oil, soya, palm oil or used cooking oil. Some of these have a carbon footprint little better than current fossil fuel diesel however, due in part to high fertiliser requirements. Bioethanol can be produced by fermenting sugars from certain plants. The carbon footprint varies and in some cases is worse than fossil fuel alternatives, but for others can achieve savings of 80 per cent. In 2003 an EU directive has encouraged Member States to significantly increase the use of biofuels. However, an increase in food prices in 2008 has been linked by some to competition from the biofuel industry. Biomass energy can be extracted from waste, either by direct burning or by biological digestion to create methane which can then be burned to create energy. This method is highly dependent on availability and price of raw materials. However it represents a sustainable use of waste products such as non-food parts of crops.

Wind farms

Mankind has harnessed the wind as a source of power for many centuries. Modern wind farms are an established technology but still have potential for innovation and growth. Wind farms refer to clusters of turbines either on-shore, near shore or off-shore. Some believe there are adverse aesthetic and environmental impacts so some projects can experience resistance from the public. This form of energy suffers from fluctuations in output and is best used in tandem with other more certain forms of production. If more cost-effective and efficient energy storage technologies can be found, the potential of wind farms would be increased.

Geo-thermal power

Heat is generated in the Earth's core and transferred to the surface where it can be collected to produce energy or used directly as a source of heating. Since the early 20th century this has been used as an industrial source of power in some regions. Energy is also absorbed from the Sun into the ground and can be used as an energy source if caught before it is re-admitted. Depending on the method used, some greenhouse gas emissions may occur but are significantly lower than for fossil fuels and can often be controlled. The technology is scalable and is relatively well developed though it has suffered from a lack of research and development in recent times. The flow of energy is reliable and uncorrelated with the weather. There are concerns around adverse effects to land stability as the nature of the subsurface can be changed; this may have insurance implications. There is little aesthetic impact as much of the infrastructure is below ground. Estimates suggest that, if used at scale, this source of power exceeds our energy needs by many orders of magnitude.

Hydro-power

Power can be extracted from the natural movement of water and has been used extensively by mankind for millennia in water wheels and dam turbines. This is a relatively

mature industry and already accounts for 20 per cent of global energy power generation. There are high upfront expenses but low running costs once operational. However, growth in this sector is often hampered by concerns on social or environmental issues such as forced resettlements or biodiversity loss, which can arise in the context of the building of very large dams. The oceans store vast quantities of energy in currents, waves and tides. Estimates suggest that the theoretical energy potential from this source significantly exceeds global electricity demand. Tidal power is a regular and certain form of power and extracts energy out of Earth-Moon interactions. Waves capture energy from the wind. Other ocean related methods include harnessing salinity gradients and temperature gradients between the surface and depths.

Nuclear power

Despite significant concerns over long-lasting waste products, risks of accidents or terror attacks, and the finite resources of uranium, some commentators have now concluded that a significant investment in nuclear power is the only viable solution for reaching ambitious emissions reduction targets. However it takes many years to build new power stations and this is not a short-term solution.

Carbon capture and storage (CCS)

This technology seeks to capture the carbon dioxide from fossil fuel burning power stations or industries; once captured the gas is transported to an appropriate location and then stored below ground under pressure. Many argue that the technology is already used in practice around the world and has been demonstrated to work; others point out that the required scale of use far exceeds existing examples. The EU expects to have a series of operational pilot plants by 2020. There are several significant liability risks with this new technology including: the possible leaching of toxic heavy metals into water systems, large outbursts of the gas might occur if the storage medium fails and, depending on the geography at the surface, could lead to wide scale asphyxia. Longer-term seepage and failure of the system may occur leading to legal arguments around product defects. Whether this risk is insurable is currently being debated.

Forestry

Forests provide a number of services to humanity including: fuel, wood for building, tourism, new medicines, water protection, soil protection, biodiversity and climate regulation. They cover some 30 per cent of the Earth's surface and provide over 70 per cent of all the carbon stored within vegetation. At present forestry, through deforestation, is the third largest source of greenhouse gas emissions, more than the entire transport sector. An area the size of England is deforested each year. By reducing the amount of deforestation and degradation of existing forests, and by increasing the amount of afforestation, reforestation and restoration, the forestry industry can become carbon-neutral while providing a significant sink of existing carbon. Addressing these issues remains one of the cheapest forms of mitigation. However, today forests are worth more dead than alive and while this is true little can be done. Overcoming this will require changes to the policy and legal framework away from deforestation incentives.

Energy efficiency

It is a vital component of the transition to a low-carbon economy. In many cases energy efficiency has been shown to be a win-win in terms of costs and benefits (as shown in Figure 5), but despite this, take-up is relatively low due to a combination of transaction

costs, lack of information and behavioural and cultural factors. The EU Emissions Trading Scheme (ETS) has been quite successful in incentivizing energy efficiency in some industrial sectors, but there is still a long way to go, particularly outside of the industrial sectors, in transport and buildings:

Transport sector efficiencies

Transport is responsible for more than a quarter of U.S. CO_2 emissions. The current petroleum based system for roads has an extensive existing infrastructure and change is unlikely to occur spontaneously. Therefore policy changes will be required to drive change. In the shorter term the introduction of ethanol to petroleum would reduce the carbon footprint. In the longer term a hydrogen or electric based system may be feasible. A reduction in carbon footprint can also be achieved by taking fewer journeys or ensuring that vehicles are filled to capacity with goods or passengers whenever possible. Stronger lighter materials can increase fuel efficiency. Public transportation systems can be especially efficient but may require new infrastructure which should be combined with smart land-use policies to avoid creating the need to travel long distances where possible. The IPCC has concluded that there are no practical alternatives to kerosene as an aircraft fuel in the short term. The contrails (ice crystals that form around exhaust emissions) magnify the carbon forcing of this fuel by 2.7 times. Ultimately society will have to significantly review its use of air travel; as the developing world becomes wealthier it is simply not feasible to cap carbon emissions and yet allow air travel to increase to meet demand.

Buildings

Buildings account for around 8 per cent of greenhouse gas emissions. The existing stock of buildings is only replaced at around 1 per cent per annum. Put another way, the majority of homes in 2050 have already been built. Therefore retrofitting of buildings is critical. Insulation can either keep heat in or out, combined with appropriate windows and modern ventilation this can increase efficiency significantly. Low-energy lighting and other appliances are essential. Use of rainwater where possible avoids using energy intensive treated water. New buildings can combine these options with modern building materials and insulated foundations to be even more efficient. After a major insurance claim there is an opportunity to rebuild both sustainably and with adaptation and mitigation in mind.

Efficiencies within other industries

The IPCC estimates that industrial processes account for around 19 per cent of global greenhouse gas emissions. Improvements in the efficiency of production processes in energy intensive industries, including pulp and paper, cement, metal smelting, mining and chemicals, have a great influence on the carbon efficiency of the global economy.

Geo-engineering

Some parties have suggested various forms of geo-engineering as a large scale solution to global warming. One example is to encourage the formation of large blooms of algae in the Pacific Ocean by introducing iron compounds into the water. The algae would fix CO_2 by photosynthesis and then sink to the ocean floor. There are huge concerns with these ideas and other forms of geo-engineering. Ecosystem and environmental effects could be material, adverse, but impossible to predict in advance. Whether such large scale engineering is insurable is questionable.

1.3 Incentivizing change

The previous section demonstrated that there are many options for reducing greenhouse gas emissions. In the cases where mitigation options will cost money it is unlikely that companies will opt to implement them while operating in a competitive market. The key problem is that today's emitters do not feel the impact of their emissions. To correct this, society must fundamentally impose a price on carbon. This can be achieved through regulating the price of emissions (e.g. through taxes) or through regulating the quantity of emissions directly (e.g. emissions caps). At the highest level there need to be binding national targets for greenhouse gas emissions reductions over the next several decades. These must first include the developed world but quickly include the developing world. Once targets are agreed governments must use a suite of incentives to cascade the required action down through society. There are currently a number of "perverse subsidies" on existing energy methods, these could be removed to equalise the playing field. The Stern Review concluded that even when technologies are available and the price signal is present, opportunities may not be taken up because of lack of information, complexity or upfront costs. The following lists some of the key methods that can be employed to incentivize further change.

Taxation and rebates

Taxation methods seek to fix the price of a certain activity. For example the climate change levy in the U.K. is a tax on energy use for non-domestic users. Energy purchased from some sources (for example renewables) is exempt from the tax. A major advantage of this method is that the cost is fixed in advance leading to greater predictability for budgeting. However the downside is that the environmental impact is not known in advance. Taxation levels can be set to approximately hit a target but can miss the mark widely. In the case of climate change the avoidance of extreme outcomes is paramount. Hence agreeing a global emissions target is critical, and this means the cost must be allowed to float. The cap and trade system, discussed next, allows for this.

Regulated cap and trade

This method works by setting a cap on the amount of green house gases that can be emitted. Companies and other stakeholders are issued credits up to a specified level of emission and the sum of all credits in the system cannot exceed the cap. Companies that need to emit more must purchase excess credits from those that manage to emit less. The cap can be reduced over time to drive down emissions. The downside is that the cost of compliance is not known in advance. However the key benefit is that the amount of greenhouse gases that get reduced is much more certain. The United Nations Framework Convention on Climate Change (UNFCCC) is a treaty that came into force in 1992. It allowed for protocols to set carbon reduction targets. The most famous of these protocols is the Kyoto Protocol which came into force in 2005. The Kyoto protocol requires legally binding greenhouse gas emissions cuts from industrialised nations. To achieve these, the protocol allows for countries to join together to form a market; for example the EU Emissions Trading is the largest trading scheme in the world. The Kyoto Protocol also created two other options for emissions reductions: the Clean Development Mechanism (CDM) and Joint Implementation (JI) projects. CDM projects are carried out in the developing world, which then sell the carbon reductions to the industrialised world. It is critical that these projects would not have occurred without the additional incentive,

and there has been controversy for some projects on this point. JI projects are similar but between two industrialised countries.

Voluntary trading

Many individuals and some companies are seeking voluntarily to reduce their own carbon footprint. Such actions create a powerful message to the industry and the public, as well as reducing emissions, and therefore are important in encouraging behavioural change. Some companies have opted to become "carbon neutral", which involves "offsetting" carbon emissions by investing in projects around the world that would otherwise not have occurred. Reputable companies require strict verification of carbon savings by an independent third party. An alternative approach is to purchase carbon credits directly from an emissions trading scheme and "retire" the credit (i.e. take it out of circulation) thereby reducing supply and increasing the cost of carbon elsewhere. Voluntary trading is a growing industry though still small in relative terms.

Grants

Actions which lead to emissions reductions can be directly encouraged by providing a grant. For example in the U.K. it is possible to get a grant to meet part of the cost of loft and cavity wall insulation.

Green funds/Green finance

Various asset management firms offer "green funds" which are baskets of equity investment comprising of companies with green agendas. Typically such companies must have clear policies around clean energy, water management, sustainability of suppliers and transport and waste management. Investment in such funds can provide new finance for such companies.

Philanthropy

A number of funds have been set up to encourage mitigation around the world. For example the Clinton Climate Initiative set up by U.S. former president Clinton is working with 40 of the world's largest cities to reduce their emissions. These are an example of where non-government groups have acted to incentivize change.

Triple bottom line reporting

Triple bottom line reporting seeks to take account of more than just financial performance in company reporting. The three aspects of this expanded accounting system are: people, planet, profit. "People" issues relate to the combined utility of the wider society affected by the company's trading and seek to demonstrate whether the utility has increased or decreased over the period. The "planet" side of reporting relates to the natural resources that have been utilised during the trading period, it will illustrate whether the business is trading in a sustainable way from a global perspective. Traditional accounting methods do not capture these issues and, as such, allow some industries to appear profitable in the traditional narrow sense. If adopted, the cost of externalities will be brought into the company's accounts.

Societal education

The more the public at large understands the enormous risks of climate change, the greater the desire for action will be. Education at all levels of society, via traditional schooling, or through a variety of media including television, films and newspapers is a key tool to incentivize change. A strong desire for action from the public will galvanise the will of politicians and businesses. Given that money must be spent now

to have security later the public must understand the reasons and be willing to make this necessary sacrifice.

2. Adaptation

Due to inertia of the climate system we are committed to certain climate changes over the next 100 years regardless of the actions taken for mitigation. Therefore it is essential that areas that will be affected adversely take steps to adapt. Several commentators have noted that many areas are poorly adapted to extremes from the current climate, hence money spent today will typically benefit current as well as future generations. The IPCC's Fourth Assessment Report (AR4) defines adaptation as "*any adjustment in natural or human systems in response to actual or expected climate stimuli or their effects, which moderates harm or exploits beneficial opportunities*". Adaptation is not exclusively focused on moderating harm from climatic effects, but also on the exploitation of "*beneficial opportunities*". One of the crucial elements of adaptation from the societal risk perspective is, according to the UNFCCC's Bali Action Plan,[80] the consideration of "*(ii) Risk management and risk reduction strategies, including risk sharing and transfer mechanisms such as insurance …*"

At a high level there are several adaptation options. One is to take no action, thereby continuing to bear the impacts as they arise. This might be appropriate for events that will continue to be very rare or sadly might be inevitable for very poor communities if they receive no assistance. Risks can be shared using transfer mechanisms such as insurance, weather derivatives or catastrophe bonds. Buildings or processes can be modified to be more resistant to adverse impacts (an example of this is to fix tiles securely to a roof to avoid wind damage in a hurricane) or to be resilient when an event occurs and to reduce recovery time (for example tiling a concrete ground floor to allow the homeowner to quickly recover after a flood). Steps can also be taken to prevent harm up to a target level of risk (for example by building a flood defence like the Thames Barrier, or relocating infrastructure out of high-risk zones) but this can be costly. Under some scenarios climate change will bring opportunities to some regions. Canada, for example, can expect its agricultural output to increase in the short term. It is important to be prepared to harness these opportunities as well as respond to threats, as they will inject some much needed growth into the global economic system.

Some impacts from climate change are quite certain in their direction (sea levels will rise), others are far less clear (e.g. we do not know how levels of rainfall will be affected in some regions). This poses a problem as investment in adaptation requires anticipating climate change impacts at a local level, and there is large uncertainty in future climate change at the local scale. For example, if drought is a concern for a particular region in future, a forest manager might plant trees that are tolerant to this. If however it turns out that the region becomes wetter such trees may do worse than the traditional alternative. Thus, in some circumstances an inadequate adaptation strategy can worsen the situation compared with a no-adaptation strategy. Such uncertainty is not going to be removed in the coming decades, the climate is inherently chaotic and while more powerful computer models will begin to improve our understanding of impacts, even the most powerful computer models will never be able to remove all uncertainty. Therefore we must plan

[80] UNFCCC (2007).

flexibly to allow for the unexpected. Where possible we should make investment decisions robust to most possible changes in climate conditions. For example, robust solutions may include identifying no-regret strategies that bring benefits even in the absence of future climate change (e.g. improved building codes and land use planning).

Governments can stimulate adaptation by targeted procurement for their own operations, which can then provide economies of scale within which nascent industries can flourish. The following groups some examples of adaptation under various themes of climate change.

2.1 Adaptation themes

Storms and flooding

Chapter 2 tells us that we can expect greater storm surges caused by both higher sea levels and stronger storms in some regions. To adapt to these effects, one option for at-risk regions is to invest in hard defences such as flood barriers or natural infrastructure such as wetlands, barrier islands and mangroves that retain floodwater, dampen storm surges and prevent coastal erosion. Building codes can also be strengthened to incorporate a number of flood and storm proofing measures including property elevation, engineered foundations, reinforced cladding and dry flood proofing. Drainage systems can be updated to cope with larger volumes of water and regions can be set aside to take the run-off of excess water. If new buildings must be built in flood zones, they can be built with the expectation that they will be flooded. An ultimate option for a region might be one of managed retreat if the region is deemed too costly to protect. Critically, early warning systems and sound evacuation strategies can reduce the human exposure to flood events; these should be made available to the developing world where human exposure is often substantial, vulnerabilities are high, and investment available for other options is often low.

Agricultural issues

We can expect some fertilisation of crops by increased concentrations of CO_2 and some additional yield from higher temperatures in some areas but these positive impacts will in many regions be more than offset by yield reductions from heat stress and water shortage. Crops are grown across the world in a multitude of different micro-climates; there are opportunities for regions to learn from one another and for appropriate crops to be transferred between locations (e.g. switching to more drought-resistant crop, if drier conditions are predicted). However, such eco-engineering may also have inherent risks as the impact of new species on an ecosystem is very hard to predict. Research and development is a key tool for understanding and managing this risk. Increased international trade will be a necessity if some regions cannot meet their food demands; however dependence on food imports means increased transport and resulting greenhouse gas emissions, and is thus undesirable if locally-grown produce is available. Diets in developed countries often include a significant amount of beef, the production of which consumes significantly more space, water and grain than other food sources. Ultimately a change in diet may be required if certain food types becomes short in availability. Biotechnology could enable varieties that are more drought or flood resistant, salt tolerant and disease resistant; again this comes with attaching ecosystem risks. Clearly the impact of agricultural risk is intimately linked to population growth; if the latter can be controlled via appropriate education then the impacts can be much reduced.

Water availability

The impacts of climate change on freshwater systems and their management are mainly due to the projected increases in temperature, sea level, precipitation variability, and drought occurrence, reducing water availability and quality in many regions. Globally, water demand will also grow in the coming decades as a result of population growth and increased affluence. The IPCC makes a distinction between "supply-side" and "demand-side" adaptation options to water management. In each case the relative benefits and disadvantages of different options depend on local circumstances. Examples of supply-side adaptation include prospecting and extraction of new groundwater sources, desalination of sea water (ideally low carbon approaches should be employed), expansion of rain-water storage and water transfer. Examples of demand-side strategies include the improvement of water-use efficiency by recycling water, rainwater harvesting, reduction in water demand for irrigation by changing the cropping calendar, crop mix, irrigation method, and area planted, expanded use of water markets to reallocate water to highly valued uses, and expanded use of economic incentives including metering and pricing to encourage water conservation. In some regions desalination and importing clean water may be the only viable solutions, however many new innovations are on the horizon.

Heat issues

In response to rising temperatures and the increased occurrence of heatwaves, one can expect increased use of air conditioning and resulting increased greenhouse gas emissions. To avoid the increasing use of air conditioning, buildings can be adapted to stay cool using low carbon approaches. Many regions around the world have already designed buildings to cope with hotter temperatures and these designs can be exported. Simple steps can be adopted for existing properties such as: fitting awnings to sun-facing windows, fans to increase air circulation, painting external walls appropriately to reflect heat. Increasing levels of heat may have impacts on tourism as some areas become less popular as they get hotter; the ski industry in particular is expected to be significantly impacted as lower slopes receive less snowfall. Heat impacts will also affect commercial infrastructure performance, for example power plants will become more difficult to cool down at a time when water is scarce necessitating back-up supplies to avoid energy shortages. Consumer practices may also change (for example preferring more cold drinks and light winter wear) and companies must be ready to react to this.

Health issues

The impact of climate change on human health is an area which requires substantial further research. Some of the projected trends in climate-change-related exposures relevant to human health from IPCC (2007) include: increased malnutrition and consequent disorders; increased population suffering from death, disease and injury from heatwaves, floods, storms, fires and droughts; altered range of some infectious disease vectors; mixed effects on malaria related to geographical range and the transmission season; increased burden of diarrhoeal diseases; and potentially increased cardio-respiratory morbidity and mortality associated with increased ground-level ozone accompanying warmer temperatures. Mass migrations which are likely in future due to many factors from rising sea levels to long term droughts, may help to spread diseases. In some regions warmer winters may bring some human health advantages such as fewer cold-related deaths amongst the elderly. Appropriate sanitation is critical to avoid some of the human health issues, and ensuring the appropriate medical supplies and education will also be important.

2.2 Incentivizing change

Mitigation must be coordinated internationally in many cases to avoid free rider issues; conversely adaptation will require many local actions, though with international coordination also to avoid duplication of effort. As such the methods of incentivisation will need to be different.

International Funding for Adaptation

Agreement on a broader funding architecture for adaptation under the UNFCCC is targeted for the Conference of the Parties (COP15) meeting in Copenhagen in December 2009. Items under negotiation include the expansion of funding sources of the Adaptation Fund to levy's on JI and EU Emissions Trading Scheme projects, the creation of a multilateral adaptation fund, a governance structure to decide how and where to spend adaptation funds, and a set of specific funding purposes (e.g. to establish regional centres of promote knowledge exchange and capacity-building, to support an international insurance funding scheme for developing countries, and to implement National Adaptation Plans). Current examples of international funding include the Global Environment Facility (GEF) which is a global partnership between 178 countries, non-governmental organisations (NGOs) and the private sector to address global environmental issues. This organisation provides grants for projects in a number of areas including climate change. Up to July 2007 the GEF had financed some US$3.3bn into climate projects mostly related to mitigation. In addition to financing its own programmes the GEF operates funding opportunities for adaptation as provided through the UNFCCC. Currently GEF oversees the Special Climate Change Fund (SCCF) and the Least Developed Countries Fund (LDCF). The SCCF has US$67 m designed to finance activities including adaptation, transfer of technology, diversification of developing countries economies away from fossil fuels. The LDCF is designed to support projects addressing the urgent and immediate adaptation needs of least developed countries as identified by their National Adaptation Plans of Action. As of June 2007 LDCF had received US$160 million in contributions; US$20 million have been allocated so far. The UNFCCC Adaptation Fund is further source of funding for adaptation under the UNFCCC that was established at the December 2007 UNFCCC COP13 meeting in Bali, and made operational a year later at the COP14 meeting. The Adaptation Fund was established to fund concrete adaptation projects and programmes in developing countries that are Parties to the Kyoto Protocol. The current fund is financed through a 2 per cent levy on the sale of emission credits generated by CDM-related emission-saving projects undertaken in developing countries, which equates to approximately US$200 million and US$300 million annually. The operating entity of the Adaptation Fund is the Adaptation Fund Board, with the GEF providing secretariat services and The World Bank serving as the trustee of the fund on an interim basis.

Public grants

As with mitigation, certain markets can be stimulated with grants. For example in the U.K. householders were encouraged to purchase water butts by their local authority at a heavily subsidised price.

Building and company valuation

Residential and commercial property valuation must take account of the value of adaptation that has been implemented. To achieve this, purchasers must appreciate the value gained by implementing adaptive measures, which may require education. Once

this occurs the costs of adaptation will be transferred to the property price. Likewise, interest rates on loans or mortgages related to properties could be reduced to reflect the lower risk to the lender of current and future climate risks.

Public private partnerships

Infrastructure projects are sometimes funded jointly between government and private business. Governments often provide initial capital for a project, or transfer ownership of public assets as payment in kind. Alternatively the incentive comes from a reduction in tax on the revenues received from the project.

Insurance pricing

Insurers that are permitted to use risk-based pricing can incentivize adaptation that genuinely reduces risk. Where data is at a sufficient granularity it is often possible for insurers to differentiate between risks. The presence of risk reduction methods (for example appropriately adapted buildings) can indicate a lowering of the severity of claims and hence justify a premium reduction. Conversely a regulatory regime that precludes risk-based pricing can lead to inappropriate responses from the public and businesses. Insurers providing liability insurance can also incentivize professionals to include climate change in their advice by recognising that those that do not do this are open to legal challenge in future that may lead to professional indemnity or errors and omissions claims.

Choice editing

Choice editing is the practice of removing certain choices from consumers. For example the Australian government has removed all non energy efficient light bulbs from the supply chain. In Japan a common approach is to pick a leading product and then require all other products to meet its capabilities as a minimum within a fixed period. This restricts full consumer choice by forcing innovation in a particular direction. In the context of insurance policy-makers could mandate the use of sustainable materials in repairs—this would add to costs of insurance and would remove the choice to use unsustainable materials.

Education

It is critical that all stakeholders are aware of climate risks but also of their options for adapting to them. For example when building work is being undertaken, either for a new property as part of general renovations or after an insurance claim, it is critical that the architect and builders advise their clients of adaptation options.

3. Summary

The economic and social impacts of climate change could be immense and in some scenarios devastating to mankind. The climate system has considerable inertia so that early action is rewarded, but sudden corrective action is hard to achieve. For these reasons there is a need for urgent and concerted global action to reduce greenhouse gas emissions and to aim for a series of targets that allow and protect against the deep uncertainties in climate predictions. There are a number of methods for reducing greenhouse gas emissions, many of which will lead to an economic saving against current practice. These include seeking energy efficiency, reducing deforestation and adopting new technologies. Such change will only occur with strong incentives from policy-makers so that the true externality cost of greenhouse gas emissions comes onto company balance sheets.

Regardless of the action taken to mitigate climate change, we can expect many decades of changing climate risks due to inertia within the climate system. Therefore the world must also adapt to the predicted impacts of climate change, especially to protect those most vulnerable. Again there are various options for adaptation ranging from doing nothing, through significant engineering to reduce risks to an acceptable level, to relocation and migration to avoid the risk. When engineering approaches are adopted it is vital to include options into designs which allow for the considerable uncertainty in climate projections. Although much adaptation must occur locally, a coordinated global framework would avoid unnecessary duplication of effort. Insurance can spread risk among society but cannot reduce its overall quantum; however by pricing according to the level of risk strong signals can be sent to encourage adaptation.

Chapter 5
Insurance and climate change—from reaction to pro-action

Walter R. Stahel, Ryoichi Nakai, Mathieu Choux and Robert Muir-Wood

The insurance industry is well advised to join the battle against global warming in a leading role.

Mr Ulrich Wallin,
CEO, Hannover Re, Germany

The insurance industry provides peace of mind for the population facing uncertainty.

Ms Stine Bosse,
CEO, TrygVesta Group, Denmark

Key messages

- **Rising levels of climate change risk will lead to higher insurance costs and reduced insurability; insurers are in danger of being on the "wrong side of the argument" in the societal response to climate change.**
- **"Turn awareness into action"—leadership in handling climate change issues will improve insurance economics as well as reduce reputation risk.**
- **Leadership includes applying the principles of risk quantification and management to inform planning decisions and incentivize risk reduction.**
- **Leadership also includes proactive support of sustainable and low-carbon economics through designing and offering new insurance solutions.**

1. Introduction

The insurance industry faces a challenge around anticipated climate change impacts. In many regions, increases in extremes will inevitably imply higher risk costs and potentially significantly higher costs of catastrophe losses. While there are also expected to be reductions in certain classes of extremes, such as severe freeze events, or spring thaw floods, overall the costs of weather-related claims, in particular from flood and drought and in some regions also from wind and fire, can be expected to rise.

Insurers also provide the best informed sector in society about risk. In an era of changing risks, insurers will need to extend their competence to provide the knowledge required to inform societal decisions around risk management. To prevent them being seen simply as the messengers of bad news around rising levels of risk, insurers will need to engage in actions to mitigate both the causes and consequences of climate change.

2. Insurance of climate perils

In considering the impact of increases in certain weather hazards on insurers it is important to recognise the difficulty of generalizing across different styles of private and government backed insurance coverage for weather risks—in particular for flood. (Flood insurance systems cover a wide range from the U.K. system in which flood is a universal private insurance coverage, to the U.S. system in which homeowners' flood insurance is only available through a federally-backed insurance system, to a French or Spanish system in which flood risk is bundled with other natural perils into a national pooling arrangement, or the Dutch system in which flood insurance is simply unavailable.) From one country to another there are also different degrees of regulation about what premiums can be charged by insurers, whether flat rated across all perils (as in France and Spain), as approved by elected or appointed State insurance regulators (as in the U.S. for hurricane wind coverage) or as part of what is, in theory, a free market (as in the U.K.).

There will also be different, and often as yet poorly predicted, outcomes around climate change impacts. However on the basis that "*the future is already here if you know where to look*", examples of situations recently exposed to elevated levels of hazards can highlight some of the trends to be expected throughout the 21st century.

2.1 Lessons from the "front line"—locations that have recently experienced elevated hazard levels

Florida and the Bahamas have been significantly impacted by a series of major hurricanes over the past decade, in particular in the two years 2004 and 2005 when there were four intense Cat3-5 hurricane landfalls in Florida. In 1992 Florida experienced the US$15.5bn insurance loss of Hurricane Andrew which led to the insolvency of 12 insurance companies and significant market disruption. The experience of Hurricane Andrew led to the creation of new State-backed insurance and reinsurance systems as alternatives to the private market—as well as the rapid growth in the use of independent catastrophe loss models (regulated since 1996) to be employed for risk pricing and accumulation management. Losses in 2004 (US$21.5bn in Florida) were largely borne by private insurers and in 2005, faced with the scientific evidence that activity rates of hurricanes in the Atlantic had shown a significant increase since 1995, the leading catastrophe modeller RMS (Risk Management Solutions) raised activity rates in its model. However the basis for

this increase in activity was not accepted by regulators while insurers, fearful of further losses, and unable to obtain the rate increases they required, pulled back from offering coastal coverage. This created an "insurance crisis" that became a principal political focus in the State in 2006. Fortunately low levels of hurricane loss in Florida in 2007 and 2008 have taken the issue off the top of the political agenda but the situation still remains precarious with some insurers withdrawing from the State, thereby expanding the role that will need to be filled by the government-backed alternatives.

The Bahamas located to the east of Florida had experienced the same hurricane climatology but had no government-backed alternative to private insurance. In the northern islands of Abaco and Grand Bahamas (hit by three major hurricanes between 1999 and 2004), flood insurance (and consequently mortgage lending) became withdrawn for some low-lying areas, and without any State-backed alternative houses have become abandoned as their value collapsed.

Another version of insurance under stress around an increase in catastrophe loss activity was played out in the U.K. as a result of regional floods across England in autumn 2000 and in two extensive flood events across England in summer 2007. Following the 2000 floods the Association of British Insurers (ABI) negotiated an increased allocation of government expenditure on flood defences and demanded a "stakeholder" role in decisions around future development in floodplains, threatening to withdraw flood insurance from locations at greatest risk.[81] Following the 2007 floods the ABI was able to demand still higher levels of expenditure on improved urban drainage and flood defences—in order to ensure that flood insurance was sustained. A policy was also developed that flood coverage would only be guaranteed where the annual probability of flooding was less than 1/75—as defined on official government- sanctioned flood hazard maps. (However flood insurance is generally being renewed for properties at higher risk.)

2.2 Insurers on the back foot

The U.K. and Florida experiences highlight differences in the potential bargaining power of insurers according to the degree to which they are full stakeholders in providing insurance coverage. Inevitably for societies faced with both the disruption of catastrophes, such as heatwaves and hurricanes, and the experience of being asked to pay for higher costs of insurance in the aftermath of a catastrophe appears as a double blow, with insurers being seen to exacerbate the direct consequences of climate change impacts. In regulated insurance markets the situation may further be inflamed when politicians refuse to approve rises in insurance rates in response to demonstrable increases in climate change costs. For some insurers the only profitable option may then be to walk away from providing insurance coverage at all. However, if insurers withdraw from providing coverage, their bargaining power with governments diminishes—and, as in Florida in 2006, the insurance industry can even become the scapegoat for the consequences of a rise in hazard.

3. Insurers as stakeholders in reducing societal risk

Faced with a situation in which rising levels of risk threaten insurability, the insurance industry urgently needs to move to a more proactive approach based on a set of key

[81] ABI (2004).

messages and objectives. Whether through work sponsored by insurers themselves, or more often through the research and risk mapping performed by independent companies, for instance with catastrophe modelling experience, the insurance industry is a principal agent in developing and employing knowledge on levels of hazard, vulnerability and risk costs. Such knowledge will become increasingly important for societies identifying how to cope with rising climate change impacts. In particular the insurance industry needs to position itself as a stakeholder in the planning process so that what gets built is fit to be insured throughout the lifetime of the property, even in situations where levels of flood or wind hazard are expected to rise under climate change.

Furthermore, insurers should become active champions of measures to reduce risk through improving the resilience of properties. A key tool available to insurers is the use of differentiated premium pricing to incentivize actions taken to reduce risk. Insurers have wide experience in employing such practices in household fire, burglary and auto insurances. For catastrophe insurance sending such signals is more difficult to achieve in practice than it might appear, as it is only possible to send pricing signals where insurance is technically rated. Even in the U.K., for example, insurers are not prepared to charge the full technical rate for properties located in flood plains, fearing that the wide variations in pricing that this would create, would open them to political charges of penalising those at highest risk. This is a pity. In the Caribbean island States for example, where the U.K. system of all perils insurance coverage is maintained, insurers are not shy of charging technical rates for risk that in some coastal locations include annual premiums set at 2 per cent (or more) of the value of the property. Only by charging technical rates for the risk is it possible to use insurance premiums to communicate pricing signals around risk reduction.

Some examples of the use of variable insurance premiums to motivate actions to reduce risk costs for extreme weather events come from Florida, where action to improve property vulnerability to hurricane winds, such as fitting window shutters and fixing hurricane straps to hold the roof down, leads to reduced hurricane insurance costs. These pricing signals are themselves derived from catastrophe model output, and inevitably show that the biggest risk (and premium) reductions can be achieved for locations with the highest hazard. The insurance industry should become active champions worldwide for the application of the pricing mechanisms for sending signals around risk reduction. However in many countries such activity will need to be preceded by active programmes of risk education, so that the need for risk-based premiums can be appreciated. (A key element of such a programme should be to gain wider recognition for the idea that property values are themselves "risk-adjusted".)

In order to send appropriate signals around pricing and compliance to improve building resilience, insurers need to determine the principal drivers of weather-related risks and in particular those situations anticipated to show significant increases in risk under climate change. Particular attention should be focused on flash flood (requiring improved drainage systems with appropriate maintenance and property specific flood defences) and wildfire hazards (requiring a cordon of vegetation removal as well as the installation of automatic sprinkler systems).

Lloyds' 360 studies are examples of work undertaken to publicise and promote the concept of incentivizing risk reduction. The *360 Risk Insight*[82] runs a series of informative

[82] *www.lloyds.com/News_Centre/360_risk_insight/*

events, covering the key themes of climate change, terrorism and liability, as well as other emerging risks such as nanotechnology and pandemics.

Through the technical risk pricing of insurance contracts, insurance can also provide valuable information for other commercial and industrial client economic actors. Understanding how risk costs may be changing provides a natural incentive for industry to take the climate issue into account in its day-to-day business and consider the benefits of reducing the risk.

3.1 Surge in liability defence costs for climate change lawsuits

Increased numbers of lawsuits can be expected to be filed against the principal emitters of greenhouse gases (GHGs) concerning the adverse consequences of climate change. Legal actions against carbon emitters have already been filed, e.g. in Japan against the automobile industry and the U.S., in which insurers are expected to support the defence costs, even while these cases appear to have little chance of succeeding. Insurers need to consider the potential implications of future lawsuits—for example where they might spread to builders or architects who have professional indemnity insurance that covers a potential liability arising from non-adaptation against rising hazards. Insurers can send important signals to industries and professions at risk of such litigation, indicating that premium increases can be expected and that the best defence against litigation is to have taken deliberate action to reduce climate change causes or consequences. For GHG emitting industries, the date from which action was taken to reduce emissions, or reduce impacts, is likely to be of great significance in determining potential liabilities, and the likelihood that a particular corporation becomes the target of a lawsuit.

4. Insurers as proactive players to reduce GHG emissions

A more proactive approach for insurers will require looking further ahead in a broader scan. Reducing the impact of climate change can also be seen to be part of the wider objective of moving to a sustainable society.

Politics is driving most of the broader initiatives today, such as the quest for a low-carbon economy in Japan and the U.K., or the United Nations Millennium Development Goals to promote the economies of least developed countries (LDCs). However, economic actors, and especially the insurance industry, should be champions of sustainability, aiming to achieve economic wealth with higher resource efficiency. In fact, insurance and sustainability have many common interests in particular around the objective of loss minimisation. Loss prevention also implies reductions in social hardship, of wasted resources and of economic losses.

4.1 Insurance as a project enabler

The insurance industry will have a key role to play in facilitating and supporting essential and innovative financing projects that promote climate risk mitigation efforts, including the commercialisation of innovations to develop the Best Available Technology (BAT). Insuring new technologies can speed up their transfer to the market place, and provides a means to establish a fair pricing of the potential emerging risks and

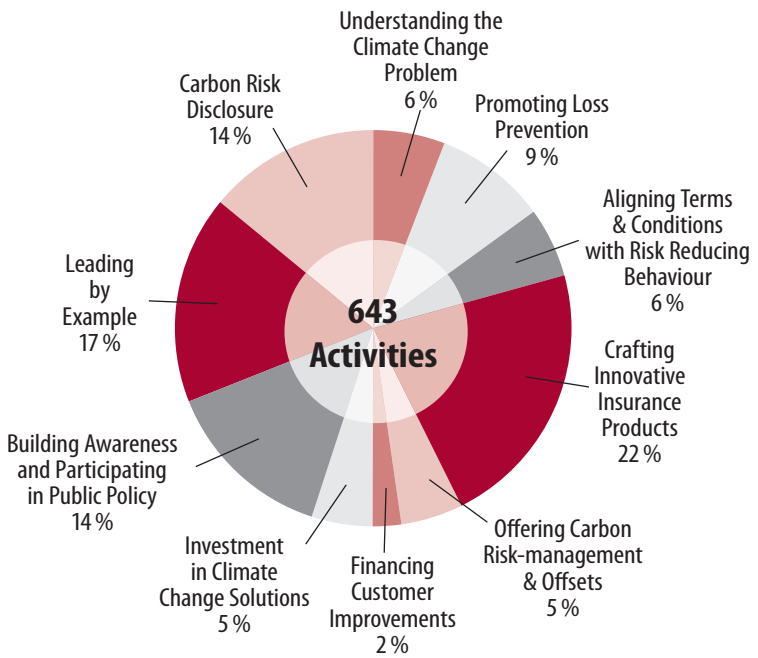
an internalization of the costs of risk by economic actors. Faced with an absence of a long record of claims experience insurers will themselves need to be entrepreneurs in determining how to price and underwrite new risk classes.[83]

Other financial instruments can also be important. Since the revenues of renewable energy power plant operators are directly indexed to the supply capacity, fluctuating weather regimes may significantly endanger their income. Thus, weather derivatives are a useful instrument for reducing the volatility of economic results.

Sustainable development and risk management have other commonalities, such as the insight that integrated preventive solutions[84] are considered more efficient than end-of-pipe solutions (an ounce of prevention is worth a pound of cure), and that sufficiency solutions are more efficient than technical efficiency (building lighthouses on dangerous rocks rather than technically equipping ships to see these rocks).

The insurance industry can therefore become a reference and benchmark for other economic actors. An analysis of the diagram below confirms this: the most frequent internal responses fall under "*crafting innovative insurance products*" and "*leading by example*".

Figure 6: Prevalence of the climate change-related activities of the insurance industry in 2008



Source: Mills (2009).

To move from the past event-based or litigation-based learning to a proactive attitude is a major challenge. Even if large insurers may have the resources to do this,[85] a tool-box-for-all is not yet available but can be sketched out.

[83] Stahel (2003).
[84] Steinberger *et al.* (2008), and also Stahel (2004).
[85] For instance the Emerging Risk Initiative (EIR) of 14 large insurers, *www.croforum.org/emergingrisc.ecp*.

5. Turning the changing (economic) environment into opportunities

Climate change is changing both the economic and the natural environment. In both cases, the insurance industry can turn the changes into opportunities. (For products and services that enable customers of the insurance industry to manage their climate change related risks and business opportunities, turn to Chapters 6 to 8).

5.1 The transition to a low-carbon economy

A low-carbon economy is driven by politics (e.g. the Eco-Model Cities initiative by the Japanese government, the UK's initiative tackling climate change[86]) and will become reality in the medium-term future. But the transition to a low-carbon economy will change the rules of the game for many economic actors and thus the insurance industry.

Three societal approaches in shifting to a low-carbon economy may be anticipated.

A first, macro-economic, approach to sustainability reflects a move towards a better management of existing physical assets, such as buildings, infrastructures and equipment. Vanguard, for instance, is Germany's technology and market leader in reprocessing specialised single-use medical equipment, such as heart catheters, as well as in-house reprocessing of medical devices for hospitals. With the shift from manufacturing to physical asset management, the quality of operation and maintenance over the full service-life of these assets dominates manufacturing quality; and the utilisation value becomes the central notion of economic value.[87]

A second, micro-economic, approach involves corporate clients adapting their own strategies to sustainability and climate change objectives for instance when manufacturers of goods become solution providers. In 2002, Panasonic started to sell the function of lighting by leasing rather than selling fluorescent lamps to customers. The "Performance Economy" internalises the costs of risk and of waste over the full service-life, by exploiting economic incentives for loss prevention and integrated risk management as they are internalising the liability for waste.[88] New opportunities for insurers open up in the area of reliability, quality monitoring and performance guarantees.

A third approach is linked to an increased decentralisation of the economy to reduce the CO_2-emissions of transport.[89] Nanotechnology will be a driver for some segments of a decentralised economy, where intermediary products (such as carbon-nanotubes [CNT] and life sciences products (e.g. medical tracers) cannot be widely shipped, or be more safely and cheaply produced locally (e.g. in chemical micro reactors). "*Safety through autarky*" is another driver for a regionalised economy: the government of New York City, for example, wants new buildings to rely on decentralised energy production, which reduces the impact of blackouts on security and society, and thus also could ensure business continuity in the aftermath of a catastrophe.

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[86] See for instance TSO (2008), or The Japanese government's Panel on a low-carbon society to discuss global warming and "Eco-Model Cities" on *http://www.kantei.go.jp/jp/singi/tiiki/080722kankyo-kouhyo.pdf*.

[87] Giarini and Stahel (1989/92).

[88] Stahel (2006).

[89] See for instance: *Financial Times* (2009).

5.2 The risks of new technologies

The technological and behavioural responses to climate change will also produce new risks. Examples include safety issues associated with a resurgence of nuclear power or the introduction of carbon capture and storage (CCS) technology. Even some "green" strategies will bring new risks, while mitigating old ones. For example defects in green building practices have been identified as potential sources of correlated liability claims.[90]

6. Creating change: crafting innovative insurance products for climate change (an inside-out view)

This section proposes new business lines with a potential to reduce climate change risks and achieve leadership in insurance products and services by opening up new business opportunities (existing examples are presented in Chapter 8). Also actions taken to support new technologies can themselves be linked with actions to reduce risk. But the low-hanging fruit may be insurance contracts with incentives for prevention or sufficiency solutions, such as:

Improved energy performance

Price will continue to drive most of the automotive sector. Incentives to drastically reduce energy consumption in cold climates, with the objective of zero energy consumption, will also eliminate the risk of freezing water pipes and consequential water damages in cases of power cuts.[91]

Automobile insurance

Potential opportunity: providing technical standardisation advice and cheap repair methods for low-carbon vehicles through joint research centres, such as The Motor Insurance Repair Research Centre at Thatcham in the U.K., to speed up market penetration.

Flood liability

Increased flooding and flash floods will tend to increase insured losses. Badly maintained or ageing water supply systems and sewer infrastructures could multiply the effects and existing underground infrastructures could be considerably more exposed to these risks.

Potential opportunities: provide incentives to companies in charge of the operation and maintenance of rainwater run-off infrastructures to become maintenance champions.

Food product liability [92]

Higher temperatures may create a greater incidence of food poisoning due to longer hotter summers, and increase the vulnerability of refrigerated transport chains.

Potential opportunity: incentivize the use of non-carbon self-governing cooling technology, such as solar-cooled refrigeration delivery vehicles (pioneered in the U.K.) to reduce losses and claims.

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[90] Mills (2009).

[91] Prefabricated zero-energy houses are commercialized in Japan by Sekisuiheim. One-off zero-energy houses exist in many countries, such as the Solar Siedlung in Freiburg, Germany. In Eastern Austria, there is a whole village that is producing more energy than it consumes.

[92] Some of these have already been mentioned in the ABI 2004 report.

7. Optimise operational functions to reduce insurance's impact on climate change

The insurance industry should also show leadership in reducing its operational carbon footprint of buildings and computer centres.

7.1 Working towards zero-carbon emissions

Insurers are among the largest owners of real estate. In the EU, 40 per cent of final energy is consumed and 36 per cent of CO_2 emissions are induced in buildings, with large potential for cost-effective savings, substantial greenhouse emission reductions and job creation.[93]

To justify upgrading the existing building stock, Life Cycle Analysis (LCA) can be used to compare the CO_2 emissions in construction and operation. The less energy a building consumes in operation, the longer the time period to reach the break-even point between construction and operation. The incentives to manage existing physical assets over long periods will thus increase. "*By retrofitting its corporate headquarters, Adobe Systems reduced its electricity use by 35 per cent and its natural gas consumption by 41 per cent. The pay-back period for the energy saving investment was 14 months.*" [94]

The energy future consists of energy efficiency, energy savings and renewable energies. The use of Best Available Technology (BAT) can reduce electricity consumption by 30 per cent.[95] Saving energy is in this case of direct economic benefit to the actors involved and greatly reduces CO_2 emissions.

The insurance industry could show leadership in designing the first zero-carbon office building to be copied by others. Few insurance companies have excelled in this area in the past. "The Gherkin", a London-based office building of Swiss Re featuring energy-efficient day lighting and natural ventilation, is a start; it is said to use half as much energy as its peers. The German Ministry of the Environment, for instance, is building its new Berlin headquarter as a zero-energy house, with its own fuel cell and photovoltaic power plant, a sewage heat pump and combined heat and power installation.

Computing centres worldwide produce more CO_2 emissions than the global aviation industry. Reducing the energy consumption of their computer centres should be of high importance for the insurance industry, through both source reduction and energy recovery (e.g. water cooling).[96]

7.2 Looking beyond a low-carbon economy

Some new buildings are designed as plus-energy buildings, or "self-sufficient power stations".[97] Plus-energy buildings use current technology to eliminate GHG emissions and feed surplus energy into networks.

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[93] EU Energy Performance of Buildings Directive (EPBD), (2002/91/EC).
[94] Brown (2008), update of 11 December 2008.
[95] According to Conrad U. Brunner, ETH Zurich; Amory B. Lovins, CEO Rocky Mountain Institute, Snowmass, CO, U.S., also *www.kaelte-effizient.de.*
[96] Koomey (2008).
[97] The first attempts of this approach date from the late 1990s (no. 4 Times Square in New York City) and was driven by architects, such as Bob Fox.

The insurance industry can act proactively by designing its new office buildings as energy autonomous units, and by giving incentives to clients constructing new buildings this way. A number of insurance sectors profit from energy autonomous buildings, including Business Interruption.

8. The power of insurers' investments

The insurance industry also acts as an investment manager. The investment product offer could include products that also target environmentally oriented companies. We have here the practical example of the Morley Fund Management's policy on climate change.[98] The group expects companies it invests in to publish an extensive and detailed report revealing their global warming contribution and their positioning on the Kyoto Protocol. The Carbon Disclosure Project (CDP)[99] is another tool for investors in gauging the performance and the attitude of a wide number of companies with respect to the carbon issue. Aside from providing options for consumers and policy-makers in putting limits on non-environmental investment, the potential economic benefit of environmentally-controlled investment for long-term products such as accumulation pension accounts could be publicised. Another promising framework is Socially Responsible Investment (SRI), which not only takes into account corporate financial performance but also performance on environmental and social criteria. Examples of SRI products include the "Sompo Japan Green Open Fund (Beech Forest)"[100] and the Responsible Engagement Overlay (REO)[101] developed by Foreign and Colonial.

9. Conclusions

The insurance industry has a key role to play in encouraging the general economy and society to develop solutions to minimise climate change impacts, by designing insurance products that incentivize actions to raise resilience, by creating innovative insurance products, adapting existing insurance policies to climate change, and as underwriters of, and investors in, future technology.

To seize the opportunities in these changes, the insurance industry should proactively discover the risk at an early stage, work on the risk control, and offer the preventive measure. At the same time, it is important to increase awareness of the role of insurance on climate change issues among the general public.

The insurance industry should also consider the benefits of a global campaign focused around risk and climate change, emphasizing its role as a trusted advisor on risk information, education and communication. As part of such a campaign it could advocate that high resolution information on climate hazards—in particular flood and wildfire—should be made universally available and accessible online. Insurers need to emphasize that climate change brings societal problems to which insurance can only provide solutions in partnership with government and business.

[98] Morley Fund Management is a subsidiary of Aviva.
[99] *www.cdproject.net.*
[100] *www.asria.org/portal/SRI_Fund/introduction.*
[101] *www.fundnets.net/fn_filelibrary//file/co_gsi_reo_public_report_q4_2007.pdf.*

The insurance industry could also team up with other like-minded institutions, such as the World Business Council for Sustainable Development (BCSD), a CEO-led, global association of some 200 companies dealing exclusively with business and sustainable development. Together with the World Resources Institute (WRI), it has founded the Greenhouse Gas Coalition (GHG Coalition). Climatewise is an example of the group of insurance companies and organisations committed to taking action to reduce the risk of climate change.

Chapter 6

The landscape of climate cooperation between governments and the insurance industry

Kim Dyrhauge Hansen

We have to face the problem of climate change together.

Ms Rosa Alegría Iñiguez,
CEO, BBVA Seguros S.A., Spain

Today's world is not ours to do with what we please; we must hold it in trust for our children and grandchildren.

Mr Donald A. Stewart,
CEO, Sun Life Financial Inc., Canada

Key message

A stronger climate partnership between the insurance industry and governments can generate considerable new potential to help society, business and households counter the emerging climate risks in future.

1. Introduction

This chapter creates an initial overview of the many possibilities for the insurance industry to support governments and authorities in addressing climate causes and consequences. It also emphasizes the preconditions that governments absolutely need to establish for a successful partnership in future. Stronger climate cooperation is essential for the benefit of the global, country-specific, regional and local society.

2. A stronger public and private climate partnership

The roadmap for the global society to a joint acknowledgement of the climate change agenda has been somewhat unclear in the past. The scientific evidence of a global climate change and its catastrophic consequences if nothing is done, has definitely grown stronger.[101] It now seems that there is the political will and leadership to address climate change causes and consequences. This follows a global trend of growing attention to climate by people and businesses around the world.

How can the insurance industry support governments and authorities to counter the growing risks and consequences of global climate change? And what political initiatives are needed from governments to support and enhance the insurance industry's climate engagement in future?

This chapter describes the initial landscape for future climate cooperation and intends to increase awareness among political decision-makers and authorities, as well as companies and organisations in the insurance industry, of ways to revitalise the relationship between the industry and governments in industrialised countries to tackle the emerging risks from climate change.

This chapter will not clarify the obvious different relationships—with regard to insurance regulation, state insurance schemes etc.—between governments and the insurance industry from country to country. The chapter postulates that despite these country-specific differences there is a potential for climate cooperation, but of course it may differ in the range of measures in prevention, claims handling, etc.

In the near future, the challenge for political decision-makers is to reach a binding international climate agreement at the end of 2009 in Copenhagen—at the COP15 (Conference of Parties of the United Nations Framework Convention on Climate Change) —to reduce greenhouse gas (GHG) emissions and thereby its long term effects on the climate. A great deal of the political attention is directed to mitigating greenhouse gas emission—the *mitigation perspective*.

The scientific evidence indicates that even if an international agreement stops GHG emissions at year 2000 levels, climate change is a fact because of past emissions.[102] So, another equally important issue on the climate change agenda is how to manage the risks for and consequences to our economy, environment and society. This underlines the absolute need for climate adaptation of our society—the *adaptation perspective*.

In effect, the adaptation perspective is a very important complementary issue on the climate agenda and of great relevance to businesses, households, etc. around the world.

[101] IPCC (2007).
[102] *Idem.*

The adaptation perspective might be of greater economic relevance for the insurance industry to focus on and especially challenge, in the short run.

Unlike the mitigation perspective, which has to be negotiated in an international and highly complex context—and of course with great importance to the insurance industry in the longer run—decision-making on the adaptation perspective will primarily be on the national, regional or local agenda. All things being equal, this may provide an easier public dialogue and positively support the insurance industry's active involvement because of a pre-established national decision-making process and well-known analytical economic tools to assess future measures.[103]

Insurance should provide peace of mind for families and communities and encourage businesses to thrive. Governments and the insurance industry clearly have a common objective to plan for overall sustainable economic growth, wealth and welfare, and therefore take into account the need for stronger climate cooperation together with other important stakeholders such as the scientific community.

3. A shared vision to counter climate change

Clearly, the insurance industry can contribute significantly to government joint efforts both now and in the future to counter the risks and consequences of climate change. Risk management in a broad sense is the core business of the insurance industry. Many aspects of insurance industry tasks will be affected by climate change in the future.

The insurance industry has a clear strategic and economic interest in addressing the problems of climate change to society, households and businesses. The industry must be equally committed to help with emerging and changing climate risks, as well as identifying appropriate responses and adaptations to the increasing consequences.

The ClimateWise Initiative—insurance committed to take climate action

Realising that the insurance sector most directly experiences the impacts of climate change, more than 40 insurance companies and organisations from the U.K.—and global companies—have engaged actively in climate actions and in the public climate debate. This is based on a truly holistic and knowledge-driven approach of all aspects of the insurers' core business.

ClimateWise was launched in 2007 by HRH The Prince of Wales who had called on the insurance industry to offer a more proactive and collaborative effort to help to reduce the risk of climate change.

The insurance industry is widely acknowledged in society as a serious risk advisor to businesses and individuals. This role can be further developed into a natural leadership in tackling the emerging and growing climate risks to society—of course in cooperation with governments, other climate-conscious businesses and private customers.

But it is also important to emphasize the necessary and overriding preconditions that both the insurance industry and governments must create for a successful partnership in future. Earlier many may have thought of insurance as an alternative to political actions on the consequences of climate change. This is clearly not the case!

[103] For more on putting climate change adaptation in an economic context, see OECD (2008).

A well thought-out and efficient international plan to reduce GHG emissions and a robust national plan for adaptation are necessary preconditions for the insurance industry to play an active role in the future, together with the governments globally. If the economy, businesses and households are not prepared for GHG reductions and adjusted to the coming climate change, insurance as we know it today will be more expensive and in some cases and areas maybe no longer possible.[104]

National governments must also develop a strong strategic regulatory framework for adaptation across various sectors in society. In some areas adaptation may simply become a condition for insurance in future. The growing climate risks will only remain manageable for the insurance industry if governments take on the responsibility to plan ahead the necessary adaptation measures. Furthermore, these have to be followed up by adaptation strategies for regional and local authorities (regions, cities and municipalities) as well.

A national strategy for adaptation to a changing climate

The Scandinavian countries have presented their overall national plans on how to adapt to the future climate. Governments in the Netherlands and the United Kingdom have also acted on the need for national adaptation policies.

Climate adaptation affects many sectors of society differently from country to country. Coastal management, buildings and infrastructure and land use planning are examples of highly influenced sectors.

For more on climate adaptation from the European Union perspective, see: *www.ec.europa.eu/environment/climat/adaptation*

A national strategy plan could give weight to some autonomous adaptations in parallel with ongoing climate changes. On their own initiative authorities, businesses and households are supposed to react in a timely manner.

But in reality, this may not be sufficient to create a sustainable economic welfare over time with changing climate risks. A precondition for private markets to function is timely, well-informed and efficient adaptation decisions.[105]

Also, problems of free riders to reasonable adaptation investments, or no sufficient individual payback for action taken by households and businesses within a foreseeable future, may hinder efficiency— resulting in an overall economic loss of welfare to society.

National adaptation strategies and plans should be followed up by long-term public spending plans with possibilities of prioritising across national, regional and local authorities. Financial constraints on public budgets might underline new forms of public private partnerships (PPP) as a good alternative in some countries to secure progress on the necessary adaptations to climate change.

A very important part of national and global policy decision-making and response to manage climate risks—also in an adaptation perspective—is qualified estimates of the costs of climate change. The insurance industry can play a more crucial role in addressing climate risks and costs.

[104] In Florida State U.S., today home-owners in coastal areas are already at risk of experiencing property insurance problems in covering damages after hurricane storms because of unfortunate circumstances between the state insurance regulation and the private insurance market. See *www.sun-sentinel.com.*

[105] OECD (2008).

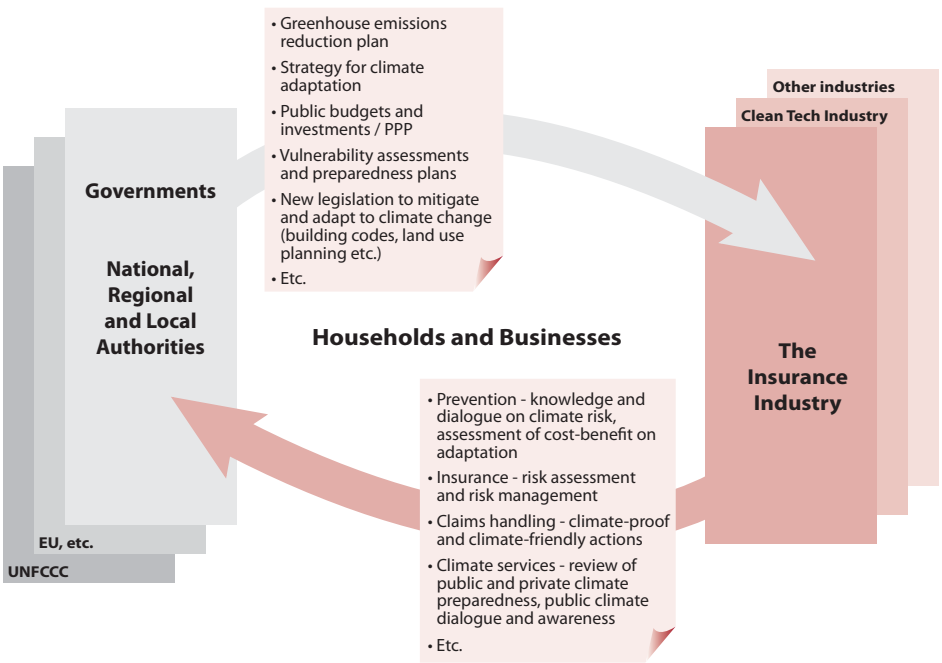
Today the insurance industry relies heavily on detailed estimates and experience of costs from climate events in the past in order to price risks and establish a sound and sustainable insurance system. The national insurance industry could go further in qualifying these climate cost assessments, especially on a regional and local level, and use well-known cost-benefit analyses to clarify the climate case. This would contribute to a stronger dialogue with governments, regional and local authorities with more detailed, proportionate and efficient climate adaptation measures as a result.

The insurance industry can definitely be considered in the large political context of business and household adaptation to climate change.

How can the insurance industry more specifically help governments and authorities? What are more specific areas for further possible climate cooperation? It seems natural to explain the possibilities from an easily understandable value chain perspective in the insurance industry: prevention, insurance, claims-handling, services and preparedness.

Figure 7 below shows an illustration of the preconditions and possibilities for stronger climate cooperation.

Figure 7: Emerging climate risk—climate partnerships between governments and the insurance industry



4. Prevention—climate change responses

Many sectors will be influenced by climate change. Some examples of the most influenced ones are coastal management, infrastructure, buildings, water and energy supply, land-planning, health and rescue preparedness.

The insurance industry could, to a greater extent, identify and assist national decision-makers in pointing out the national regulatory framework that needs to be revised according to a mitigation and adaptation perspective on climate change, e.g. building regulations, land planning, prevention measures.

A climate change response—where and how to build

The Association of British Insurers (ABI) in the U.K. has actively engaged in encouraging the integration of climate risks into future development decisions.

ABI has published a guide to help developers, planning authorities and people considering buying new property to ensure that new developments rise to the challenges presented by climate change.

For more, see *www.abi.org.uk*

A sector influenced by climate change is buildings and infrastructure. Heavy downpours can flood basements and affect drainage, sewers, roads, tunnels, etc. Warmer summers and wet winters may pose a problem to the indoor climate. Stronger storms may affect houses and bridges.

Managing flood risks in the European Union

In 2007, the European Parliament and the Council of the European Union passed a new directive on national assessment and management of flood risks in countries in the European Union.

The objective is to establish a framework for the assessment and management of flood risks.

The Member States must prepare:
- preliminary flood risk assessments,
- maps of danger and floods risks, and
- plans of risk management and precautionary measures

With its strong risks knowledge, the insurance industry could engage in a broad dialogue with governments and authorities—and also with customers and the public in general. New constructions must take into account the climate change over time. Existing construction must be adapted, and/or climate change must be integrated in more economically efficient way in maintenance investments plans, e.g. maintenance of local drainage and sewer systems.

A broader and analytically qualified dialogue between stake-holders on all possibilities of measures for prevention may also prove more economically efficient.

There may be a public tendency to focus on more structural measures of adaptation to climate change, e.g. the need for investments in higher dikes or completely new sewer systems, where the solutions may in reality lie with better land planning, or very local sewer improvements, or simply better information to insurance customers on how to prepare their homes and valuables for heavy downpours. Behavioural adaptations may be part of the total adaptation needed, thereby lowering the overall cost to society and the insurance industry.

5. Insurance and the emerging climate risk

Insurance can also be a means of encouraging climate adaptation in businesses and households in a limited context.[106] Price signals in an insurance market might push households to make difficult decisions sooner.

Anticipated premium deductions on the home insurance for a group of home-owners could act as a local incentive to improve a local drainage system, and still secure a sound link between risks and premiums. Furthermore, the extent of insurance coverage of the insurance can also be managed to address possibilities for climate adaptation. Or finally, for example, alternatively a higher premium on home insurance in especially high flood-risk areas may put pressure on the local political decision-makers in municipalities or cities to act on the public need for a new efficient drainage system.

In general, the insurance industry and governments could engage in a closer dialogue on more specific changing climate risks based on actuarially sound risk-based pricings in the insurance industry that send appropriate risk signals to consumers and businesses. Of course this depends on the country-specific insurance schemes and regulations.

In the future, higher frequency and severity of extreme weather events could make it increasingly difficult to share the economic loss with the insurance industry alone.

Some climate risks might be non-insurable, and the extreme alternatives are that risks become fully individual or that governments nationalise the risks. Neither alternative is desirable in any case.

The insurance industry and governments should join forces in reviewing and analysing financial possibilities under a more extreme climate change scenario to secure a continuing well-functional private insurance market with easy and affordable access for businesses and individuals.

Additionally, by promoting certain climate friendly behaviour for businesses and individuals, the insurance industry and governments could strengthen their partnership to achieve better results.

Examples of partly insurance-driven innovation to achieve more sound and rational behaviour of the insured are well known from other sectors of society. The process is known from national authorities' and other relevant stakeholders' common efforts to secure higher safety on roads and seas for people and the environment.

6. Sustainable claims-handling

Every year, the insurance industry has claims totalling several billion US$. Part of the total claim costs are pay-outs on damaged cars, homes, etc. These are sectors of society that today directly add to climate change by energy consumption and carbon emissions. The substantial claim costs every year in the insurance

Climate-friendly claims handling—government action

In Denmark the government has decided to prepare a new building regulation to achieve more energy-efficient buildings in future. By 2020 all new buildings should be 75 per cent more energy-efficient than today. This is important when insurers support reconstruction on a new building based on new regulation after, for example, a fire.

[106] Lloyd's (2008).

industry underline the huge potential to take climate-friendly (mitigation perspective) and weather-proof (adaptation perspective) action.

The insurance industry has a strong potential to guide and engage customers and suppliers on alternatives in claims-handling that are more climate-friendly and weather-proof.

Governments could also more actively support a more climate sustainable claims-handling process though the regulatory framework or/and the right economic incentive structure—especially in the sectors of the economy of high relevance to the climate agenda.

Evidently, the insurance industry also has an economic interest in new research and development (R&D) in technologies that increase the development of weather-proof measures to prevent damage recurring, e.g. more hurricane- or flood-resistant constructions when rebuilding in these high-risk areas.

7. Climate services and preparedness

U.K. flooding in the summer of 2007

The most severe weather-related event in decades in the U.K. was the floods of summer 2007. The insurance industry covered around £3 bn of losses and received around 180,000 claims.

Based on this event, the U.K. government and the Association of British Insurers have agreed on an extensive action plan to manage the flood risks to people and property better in future and ensure the long-term availability of flood insurance.

For more, see *www.abi.org.uk*

Finally, the growing climate agenda might be a natural starting point for more extensive focus on the insurance industry's services to customers – especially preparedness in the event of major weather-related catastrophes. The same can be said about the emergency services of the national, regional and local authorities.

Often there are many private and public stakeholders including various government levels which are of critical relevance in case of weather-related events. Additionally, there will typically be various advisory bodies on necessary climate prevention.

Governments, and the insurance industry, should initiate and facilitate an overview of the existing national preparedness systems in relation to climate change risk and should provide the public with easy access to this information.

Businesses and households should be in a position to assess and discuss their own risks from climate change, and should be able to form their own opinions on the public and private preparedness before weather-related events.

An annual Vulnerability Report

Annually, the Danish Emergency Management Agency (DEMA) prepares a national vulnerability assessment in order to learn more from actual events.

The objective is to share experiences and assess various improvements of society's preparedness to changing demands made by societal and external events, e.g. climate change.

For more, see DEMA homepage: *www.brs.dk/uk/*

8. Conclusions

This chapter has given an initial overview of the many possibilities for the insurance industry to support governments and authorities in addressing the causes and consequences of climate change. The potential for a climate partnership lies in a range of measures on prevention, insurance and risk management, more climate-wise claims-handling, and services promoting public awareness and preparedness.

It has also emphasized the preconditions that governments absolutely need to establish for a successful partnership in future. Governments must establish an international agreement and commitment to reduce greenhouse gas emissions, and a well-founded national strategy for climate adaptation across various sectors in society. Governments and authorities must also demonstrate willingness to reconsider climate vulnerability assessments and new legislation to mitigate and adapt to climate change (buildings codes, land planning, finance, etc.).

Stronger climate cooperation is essential for the benefit of global, country-specific, regional and local society. A shared vision and a stronger climate partnership can definitely enhance insurance industry and governments possibilities for joint engagement in climate actions.

Chapter 7

Climate change and emerging markets: the role of the insurance industry in climate risk management

Koko Warner and Andreas Spiegel

Stable climate and peace go together.

Dr Carlo Acutis,
Vice President, Vittoria Assicurazioni S.p.A., Italy

Climate change will change the way we live and work, and will lead to greater competition for scarce resources, such as food and water. This is likely to result in increased economic nationalism and greater global insecurity, which will in turn add to the complexity and cost of doing business.

Dr Richard Ward,
CEO, Lloyd's, U.K.

Key message

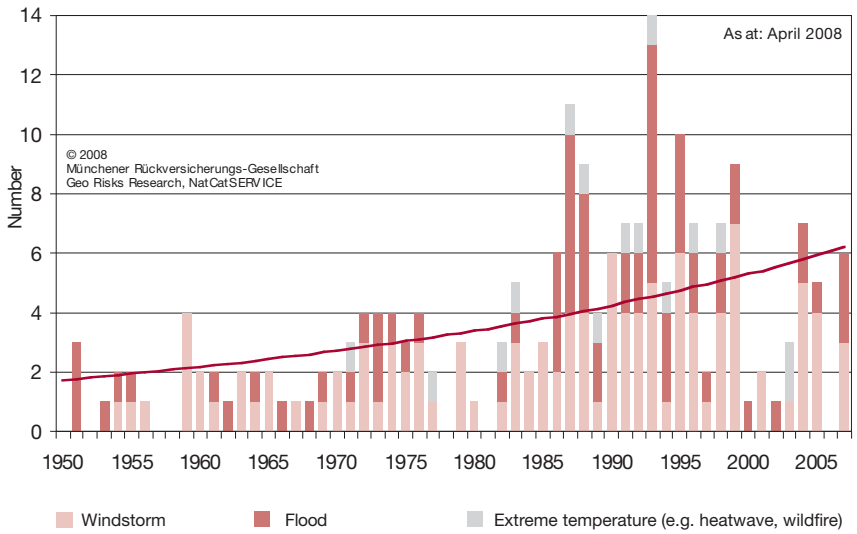
Climate change brings new risks but also new opportunities for the insurance sector. Risk management options are needed more today than ever, yet questions arise about how the industry can contribute to solutions in the challenging context of higher risks, greater uncertainty and less well understood situations in developing countries.

1. Climate risks and the insurance sector

Weather-related risks play an important role for the insurance sector. Climate change alters the probability of weather-related extreme events, often increasing the frequency and/or intensity of such events. According to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change,[107] human induced climate change trends will continue to have a major influence on weather related risks. In general, the weather will become more variable and extreme. Increasing hazard frequency and intensity cycles, probably, associated in part with an underlying climate change trend, increase the potential for losses. The insurance sector will need to quantify this emerging trend where applicable and include the findings into its risk calculations, pricing and underwriting.[108]

Global weather-related insured loss experience since 1990 shows a clear upward trend. Reasons for this trend are largely socio-economic: factors like economic growth, increasing population densities and insurance penetration, value concentrations in coastal areas, and increasing vulnerabilities of insured values contribute to rising weather hazard-related losses worldwide. In the record hurricane year of 2005, insured weather-related losses averaged approximately US$100bn due to major events such as hurricanes Katrina, Rita and Wilma.[109] These insured losses stem only from "great disasters", and may be less than half of the total insured losses worldwide.[110]

Figure 8: Great weather disasters 1950 - 2007



Source: Munich Re, NatCatSERVICE.

Thus a dual challenge, and opportunity, faces the insurance sector and society. First, most of the factors related to increasing losses are not climate-related, but societal in origin, thus increasing the need for effective and integrated risk management and

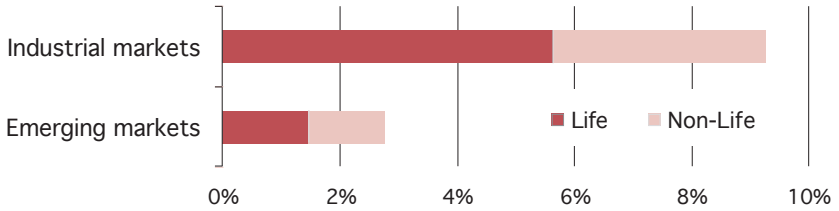
[107] IPCC (2007).
[108] Charpentier (2008).
[109] Munich Re (2007).
[110] See Dlugolecki (2007).

risk reduction.[111] Risk reduction efforts, if effective, can help maintain insurability as the proportion of risk attributable to climate change rises through time. Second, there is a need and a market niche to develop insurance solutions for areas facing increasingly frequent and intense weather-related hazards.[112]

1.1 Growing need in emerging markets for insurance tools to manage climate risks

Developing countries will be most severely impacted by climate change. At the same time, developing countries often lack the required financial infrastructure, such as banking and insurance systems which help governments, middle-income, and low-income clients like small farmers to financially cope with disasters. This is reflected in the latest numbers of the current global density for non-life insurance. Current insurance penetration in terms of premiums in percentage of GNP amounts to roughly 4 per cent in industrial markets, whereas in emerging markets it amounts to less than 2 per cent (see Figure 9).

Figure 9: Insurance penetration 2007 (premiums in % of GNP)



Source: Swiss Re (2009).

Losses from natural disasters are typically absorbed by individuals, corporations and insurers. In case of low insurance penetration (e.g. in emerging markets) insurers only absorb a fraction of the losses. As a consequence, there is a considerable gap between economic and insured losses. In addition, disasters often result in a decline in output growth, a loss of capital and durable goods, lower tax revenues, government deficits, increasing indebtedness, higher inflation and currency movements.

Expressed in losses this means that in 2008, natural catastrophes and man-made disasters claimed more than 240,500 human lives worldwide and caused total losses of approximately US$52.4bn, third in record after 2005 and 2004, the years of series of hurricanes. Issues such as poor data, inadequate or missing regulatory frameworks, high claims adjustment costs, moral hazard and the lack of financial means to pay a premium all make the implementation of traditional insurance concepts difficult.

According to the United Nations,[113] the estimated global adaptation cost per year by 2030 will amount to US$49-171 billion, from which US$28-67 billion will be required in developing countries.[114] The United Nations Framework on Climate Change Convention (UNFCCC) and the Kyoto Protocol established several funds to finance

[111] Ward *et al.* (2008), Maynard (2008).
[112] Dlugolecki *et al.* (2009), Mills (2007).
[113] United Nations (2008).
[114] Smith (2007).

concrete adaptation projects and programmes in developing countries. Currently available adaptation funds from UNFCCC and the Kyoto Protocol will amount to roughly a few hundred million US dollars per year—clearly not enough to fully finance all adaptation needs. If funding remains at current levels, it will not be sufficient to address future costs.

1.2 Risk reduction and private sector participation

New, innovative insurance instruments can play an important role to help bridge some of this adaptation financing gap by helping to reduce the costs associated with climate extremes and transferring those risks through insurance mechanisms where they can be reduced efficiently.[115] They can be applied on a macro-level, for instance as catastrophe bonds (cat bonds) to tap into capital markets to help fund the cost of recovery on a national and international level, or they can be applied on the micro-level, for instance as index-based weather risk transfer instruments, to cover against weather related risks for the agricultural sector. Micro-insurance products can be embedded into micro-credit products, thereby greatly facilitating access to financing for individual farmers, reduce poverty traps, and increasing resilience to shocks.[116]

Additionally, insurance services enable investment and development: when the public sector has finite resources, as many do in developing countries, the case has been made that risk-sharing schemes like insurance can spread the burden of replacing a given asset to a third party if a hazard occurs.[117] Insurance can allow a government to invest more effectively in economic and social development projects because it need not maintain such large reserves or go into debt in case it must replace an asset (the case of self-insurance). Risk engineering services provided by the insurance sector can help grow markets that have no insurance yet, and there are multiple benefits of risk reduction for insurance sector involvement in developing countries. Insurance can facilitate investment in mitigation as well. For example, insurance can facilitate investment in Clean Development Mechanism (CDM) projects which require credit to plan and implement projects. Banks may be reluctant to offer credit for projects with a longer life span or which require multiple steps—the presence of insurance can reduce the risk to banks of losing their capital and help spread the implementation of CDMs.

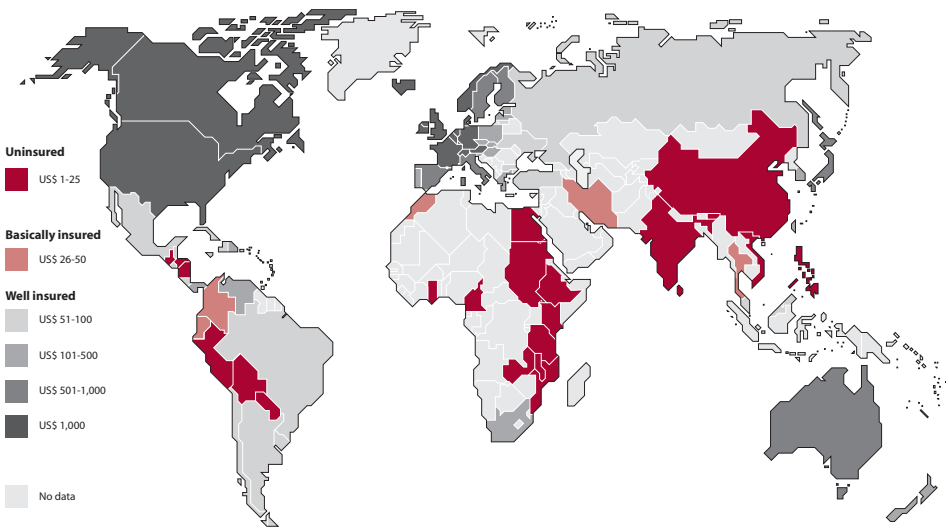
Risk management options are needed more today than ever,[118] yet questions arise about how the industry can contribute to solutions in the challenging context of higher risks, greater uncertainty, and less understood situations in developing countries. An integrated risk management perspective will be required to deal with these challenges and opportunities. A global adaptation framework will need to ensure financing of risk assessment and the implementation of risk prevention, reduction and insurance transfer solutions to benefit those most vulnerable to the adverse impacts of climate change.[119]

[115] Bouwer *et al.* (2007), Höppe and Gurenko (2006), Kunreuther (2006), Benson and Twigg (2004).
[116] Barnett *et al.* (2008), Cohen and Sebstad (2003).
[117] Arrow and Lind (1970).
[118] See e.g. Stern (2007).
[119] UNFCCC (2008a).

2. Ways insurance schemes address climate risks today

Today insurance penetration in developing countries, however, remains very low, illustrated by Figure 10 below. Yet catastrophe insurance has the potential to play a larger role in developing countries. Some initial, innovative public private initiatives undertaken by the World Bank, international donors, and some (re)insurance companies demonstrate potential to pool the management of weather variability and climate extremes, as well as transfer risks to the global capital markets. Some well-known examples are presented here, many other examples exist.

Figure 10: Property insurance premiums (non-life including health) per person and per year



Source: Munich Re (2006).

2.1 Risk pooling among countries

At the meso or regional level, the Caribbean island States recently formed the world's first multi-country and index-based catastrophe insurance pool to provide governments with immediate liquidity in the aftermath of hurricanes or earthquakes.[120] The Caribbean Catastrophe Risk Insurance Facility (CCRIF) has had almost equal years of paying out and not being triggered—in 2007, the CCRIF paid out US$1 million to Dominica and St. Lucia, and is scheduled to make a payout of about US$6.3 million to the Government of the Turks and Caicos Islands for damage incurred from Hurricane Ike during the 2008 Atlantic hurricane season.

2.2 Public private partnerships at the country level

Countries are also using insurance-related mechanisms, e.g. the World Food Programme piloted an index-based drought insurance scheme for government relief

[120] Ghesquiere *et al.* (2006).

expenditure in Ethiopia. Future transactions may include a catastrophe bond, which pays an above-market interest rate if rainfall exceeds a specified level, but part of the principal would go to the Ethiopian government if rainfall is below this level.

2.3 Micro-insurance solutions

Micro-insurance tools for weather risks are showing good potential to reduce the vulnerability of the poor to climate risks. Innovative index-based insurance solutions can play an important role in this context. They can be applied on a stand-alone basis as risk financing instruments that provide effective and timely disaster assistance from the national to the local level, or they can be embedded into credit products, thereby greatly facilitating access to financing for individual farmers. Payments are triggered based on parameters like rainfall, temperature or vegetation measurements. This has the advantage over traditional indemnity-based products in that farmers are provided with disaster assistance shortly after the disaster (e.g. drought) has occurred. The farmer does not have to wait until a claim has been verified. Moral hazard is largely removed, and clients avoid debt or ruin associated with crop failure. These features make this tool attractive to potential capital providers.

In Malawi, smallholder farmers can buy affordable index-based drought insurance. The insurance is linked to loans and both improve the credit-worthiness of participating farmers and enable them to increase their farm productivity.[121] Many countries are gaining experience with insurance products, as illustrated in the text box below.

Swiss Re has helped pioneer index-based weather risk transfer instruments in low-income countries, starting in India in collaboration with a micro-finance institution and a local insurer in 2004. A total of 350,000 policies have since been sold to smallholder farmers in India. In Africa, such solutions have been successfully deployed to protect poor farmers against climate risks. For instance in 2007, Swiss Re successfully designed and implemented index-based weather risk transfer instruments for three village clusters in Sauri (Kenya), Tiby (Mali) and Koraro (Ethiopia) protecting 150,000 farmers against drought risk. The markets for micro-insurance are growing rapidly, and many other companies are active in pilot projects, including AXA, Allianz, Munich Re, MicroInsure, Zürich, etc.

In 2007 the Caribbean Catastrophe Risk Insurance Facility (CCRIF) was launched, covering 17 islands against hurricane and earthquake losses. In 2008 the programme´s reinsurer group has been diversified through the inclusion of Swiss Re, in addition to the existing underwriters which include Munich Re (lead reinsurer), Paris Re and Hiscox of Lloyd's. The World Bank Treasury (through the International Bank for Reconstruction and Development – IBRD) has arranged for CCRIF to transfer a portion of the catastrophe risk to the capital markets through a cat swap transaction.

Catastrophe insurance—with international support—has potential for providing security to the poor. Coordinated public private action can help provide the needed security in the face of climate related hazards.[122]

[121] Hess and Syroka (2005).
[122] Linnerooth-Bayer *et al.*(2005).

3. Climate change negotiations: insurance in a post-2012 adaptation deal

Several developments in the international community are relevant for the insurance sector, for example the United Nations International Strategy for Disaster Reduction (UN/ISDR) works with the governments of developing countries to help them reduce risk from natural hazards. More broadly, the Millennium Development Goals (MDGs) aim to reduce poverty and other major factors that affect vulnerability in developing countries. Over time these efforts, if effective and in conjunction with economic growth, will go far in helping developing countries build resilience to climatic changes and risks associated with it.

This section focuses on one international process, the climate negotiations, and how insurance mechanisms are considered there. Insurance has been mentioned in the 1992 Convention (article 3.14), the 1997 Kyoto Protocol (article 4.8), and the 2007 Bali Action Plan. The Bali Action Plan (BAP) calls for "*consideration of risk sharing and transfer mechanisms, such as insurance*" to address loss and damage in developing countries particularly vulnerable to climate change.[123] At the 2008 climate talks in Poznan, Poland, insurance was one of the major items of discussion on the adaptation agenda, and was mentioned over two-dozen times in the draft text which negotiators consider as they begin to fit the puzzle pieces together. The many elements proposed between Bali and Poznan must be fitted together in a coherent framework that will become the agreement that defines the new commitment period after the Kyoto Protocol.

3.1 Insurance in the Copenhagen Agreed Outcome

The climate negotiations taking place in Copenhagen in December of 2009 will establish the architecture for the agreement that will extend beyond the Kyoto Protocol when its first commitment period expires in 2012. The new agreement, the Copenhagen Agreed Outcome, will include both targets for the reduction of greenhouse gases (mitigation), and a framework to facilitate adaptation to the negative effects of climate change. It is under the adaptation agenda where insurance solutions are now under serious consideration.

For the inclusion of insurance instruments in the post-2012 adaptation regime, the potential role of financial risk transfer systems must be firmly established. The emerging negotiating text suggests that an insurance component should (1) follow the principles set out by the UNFCCC for financing and disbursing adaptation funds, (2) help those countries particularly vulnerable to the impacts of climate change, and (3) include private market participation.[124]

3.2 Insurance proposals and risk management are part of adaptation solutions

At the 2008 climate talks in Poznan, negotiators stressed the need for risk management, including insurance as an element of risk management, in the architecture of the Copenhagen Agreed Outcome.[125] Numerous proposals have been put forward during

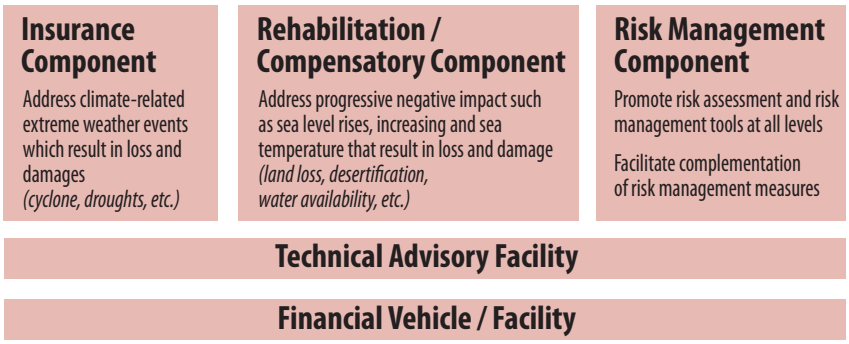
[123] United Nations (1992, 1997), UNFCCC (2007a and b).
[124] Bals *et al.* (2006).
[125] UNFCCC (2008a and b).

the climate negotiations that mention insurance. Most recently proposals have come from countries like Switzerland, Mexico, some countries of the European Union and further ideas from Bangladesh (for the LDCs), China, India, Argentina, the Philippines, Malaysia, Saudi Arabia and other countries, and from observers like the Munich Climate Insurance Initiative (MCII), the Climate Adaptation Network (CAN), and others. Two detailed insurance-related proposals were tabled by the Association of Small Island States (AOSIS) and the MCII.[126] The two proposals explore how risk management including insurance mechanisms could fit into a longer-term adaptation financing framework (i.e. post-2012).

Overview of AOSIS and MCII proposals

The AOSIS and MCII proposals are presented in Figures 10 and 11.[127] Both proposals are based on the premise that risk prevention and risk reduction are the point of departure for managing climate-related disasters. When effective risk reduction is in place, insurance can be a complementary measure to facilitate adaptation. The MCII proposal has similar characteristics to the framework outlined by AOSIS, with the AOSIS proposal adding the component of rehabilitation to their proposal.

Figure 11: Elements of the AOSIS Proposal



Source: Mace (2008).

Figure 12: Elements of the MCII Proposal

Source: Warner (2008).

[126] MCII, which was initiated in 2005 by Munich Re, is an independent, non profit association of researchers, representatives from insurance, NGOs, the World Bank, and experts.

[127] AOSIS (2008), MCII (2008).

The AOSIS proposal asked the climate negotiators to create a multi-window mechanism with three components to address loss and damage from climate change impacts: insurance, rehabilitation, and risk management. The insurance component aims to address losses and damages from rapid onset climate-related extreme weather events such as hurricanes; the rehabilitation or compensatory component is directed towards loss and damage (e.g. land loss and coral bleaching) from progressive cumulative adverse impacts such as sea level rise; and the risk management component promotes preventive action using risk assessment and risk management tools and strategies at all levels. These three components would be supported by a financial and a technical support facility. While the proposal does not detail where that technical advice might come from, the insurance sector would likely be involved in such activities if it were part of the Copenhagen Agreed Outcome.

The MCII proposal consists of two components in a larger framework of risk management: risk reduction and insurance. Low-level risks are often effectively addressed by risk reduction and prevention measures. The estimated cost of the prevention pillar is US$3bn dollars per year. Risks at the medium and high level can be addressed by insurance measures that complement and incentivize risk reduction and prevention. MCII´s proposal therefore envisions two tiers in the insurance pillar: a Climate Insurance Facility to catalyse nascent risk sharing and risk transfer systems including micro-insurance at the medium-level of risk. The estimated cost for a Climate Insurance Assistance Facility is US$2bn per year. A Climate Insurance Pool for high-level risks will address a pre-defined portion of losses from large weather catastrophes. The Climate Insurance Pool will be reinsured against extreme loss years in the global reinsurance market. The estimated cost for the Climate Insurance Pool including reinsurance is estimated to be around US$5bn per year.

The AOSIS proposal and the MCII proposals have significant complementarities, as can be seen by comparing figures 10 and 11 above. Both proposals take a wider perspective of *reducing the vulnerability* of developing countries to climate change impacts. Both proposals have elements including *risk reduction* (called "risk management" in the AOSIS proposal and "prevention" in the MCII proposal), and elements of *insurance*. The AOSIS proposal is framed in terms of providing developing countries a set of tools that will help them address the negative effects of climate change now and in the longer term.

4. Key questions about implementing insurance solutions in developing countries

Adaptation needs depend on the specific risk landscape of a region or country. Insurance has an important contribution to make in this area, particularly because of the industry´s experience in assessing and pricing risk.[128] Some of the following questions arise about how to implement adaptation measures that encourage risk reduction and management, including insurance:

- How can adaptation needs in individual countries be determined?
- How can different risk prevention, reduction and transfer measures be selected and implemented in an integrated adaptation strategy?
- When is it advisable for developing countries to insure against climate related risk?

[128] Gurenko (2004), MMC (2005), Kartha *et al.* (2006), Skees *et al.* (2008).

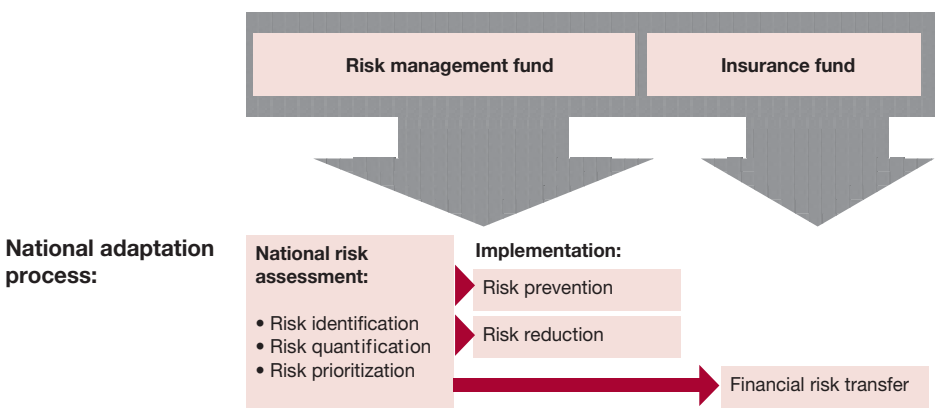
- When is it advisable to protect against climate-related risks through prevention and risk reduction measures?

UNFCCC has launched the National Adaptation Programmes of Action (NAPAs) process covering some of these questions for LDCs. NAPAs provide an overview of priority activities that respond to urgent and immediate needs to adapt to climate change and are supposed to use existing information (no new research), be action-oriented (projects) and to be presented in a simple format, easily understood both by policy-level decision-makers and by the public. As of October 2008, the UNFCCC secretariat had received NAPAs from 38 LDCs. The qualitative results do not support countries in answering the questions above in detail or in allowing insurance companies to develop and structure insurance solutions.

From an insurance perspective, adaptation needs depend on the specific risk landscape of a region or country. Integrated risk assessment helps ensure prudent investments in well designed adaptation measures suitable for addressing local climate risks. From an insurance perspective, specific weather-related hazards will need to be identified, quantified and prioritised on a local level. For example, to determine overall risk landscape in a specific location key hazards such as flood, storm, drought, and sea level rise must be identified, frequencies and associated economic losses of each hazard need to be determined and a loss/frequency relationship (risk pricing) will need to be established.

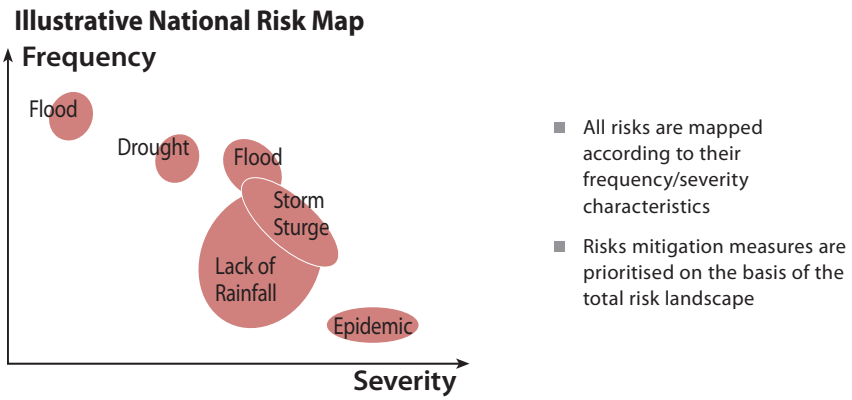
An adaptation financing framework that includes such a local risk assessment perspective will allow each country to prioritise future adaptation measures and to determine its overall strategy in a cost-effective way. Ideally a post-2012 adaptation financing structure should provide the funds for a comprehensive local risk assessment effort and for implementing the adaptation strategy through risk prevention (capacity-building, building codes, regional zoning and planning), risk reduction (technical, infrastructure projects) and financial risk transfer measures (e.g. insurance solutions, capital solutions) as illustrated in Figure 13 below. Both the MCII or the AOSIS proposals, or additional proposals that may be tabled, would be suitable to finance local risk assessment and implementation measures in this manner.

Figure 13: National risk assessment and distribution of funding for adaptation



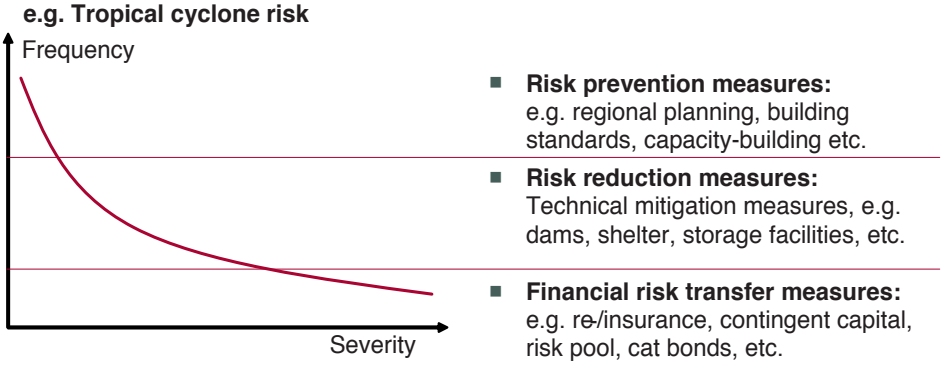
The assessment and pricing of regional climate risks would result in national risk maps (as illustrated in Figure 14), which illustrate the severity of risks (hazards x vulnerabilities x exposure) and provide a basis to develop a national adaptation strategy.

Figure 14: Frequency and severity of risks affecting national adaptation strategy



Risks should be managed through a combination of risk prevention, reduction and transfer measures. The combination of measures will depend on the associated hazard frequency and on the associated economic losses. In principle, it may be most-cost effective to undertake preventive and risk reduction activities for high frequency/low severity events, while low frequency/high severity events may be financially transferred in combination with prevention and reduction measures (as illustrated in Figure 15). Depending on the magnitude and timescale of potential risks and liabilities, State solutions would need to be included in risk transfer solutions with very high severity potential.

Figure 15: Frequency and severity of risks help prioritise adaptation activities



5. Next steps—what is needed from an insurance perspective

Climate change brings new risks but also new opportunities for the insurance sector. The sector has the potential to catalyse global efforts to adapt to the risks associated with climate change, and incentivize appropriate risk management. Although at the moment only few and often small-scale piloting solutions have been implemented in developing countries, the insurance sector is uniquely positioned to provide necessary services for countries and businesses facing climate risks, especially in the developing world. The insurance sector has the concentrated expertise necessary to address some of the technical challenges associated with changing historical weather patterns, pricing and managing climate risks, or identifying risk reduction opportunities as the insurance sector.

5.1 The road to Copenhagen—what are the critical points for the insurance sector?

At COP14 in Poznan, the adaptation agenda highlighted risk management including insurance-related mechanisms.[129] The climate negotiations in 2009 will determine whether insurance is described in terms of a formal mechanism. Parties expressed great interest in the potential of insurance, and large areas of complementarity emerged in both proposals tabled by AOSIS and MCII, as well as the many Party submissions mentioning insurance. All Parties that expressed their views related to insurance showed agreement that risk management and reduction is the main focus, with insurance tools needed to incentivize risk reduction and involve the private sector. One delegate noted "*A Copenhagen Agreed Outcome without an insurance element would not be complete*."

6. Final remarks

From Poznan to Copenhagen, Parties will design the overall architecture of a post-2012 climate agreement. The stage is set for insurance solutions and the insurance sector to contribute tangibly to managing climate risks and facilitating climate adaptation. Already today, many examples exist of insurance solutions for communities, countries and groups of countries that foster greater resilience to climate risks. Yet, insurance alone will not address all adaptation challenges that arise with increasing climate risks, like desertification or sea level rise.[130] It can, however, be a strong complementary mechanism in a wider adaptation framework.

For a global adaptation framework to be successful, the following key points would need to be established:

- Agreement of a global post-2012 adaptation architecture, which includes insurance solutions in a wider framework of risk management;
- Agreement on the use of integrated, local risk assessment as a basis for selection and implementation of adaptation solutions;
- Agreement on a governance structure which ensures efficient access by developing countries to available United Nations adaptation funds.

[129] See, for example IRIN (2008).

[130] An UNFCCC paper from 2008 and the AOSIS proposal contain some ideas of how quasi-insurance could deal with "uninsurable" risks like desertification and sea level rise.

Parties will have little time to work out the technical and governance details of necessary risk sharing and risk transfer schemes including insurance. There is therefore a great need for the private sector to become involved, share examples of what has worked (or not) and why, and engage in greater dialogue with Parties that are particularly interested in insurance. It is important that the framework for insurance be established in ways that allow healthy market growth after an initial agreement is sketched out in Copenhagen.

Chapter 8

Leadership by insurance—how the insurance industry can establish best practices in its business models related to climate change

Tokio Marine & Nichido Fire Insurance Company
(Corresponding author: Hiroyuki "Rocky"Hata)

The insurance industry is at the beginning of the learning curve with regards to climate change and new products.

Mr Bruno Pfister,
Group CEO, Swiss Life, Switzerland

Climate change is a great challenge to use our loss prevention capabilities in a proactive way.

Mr Asmo Kalpala,
Chairman & President, Tapiola Group, Finland

Key message

The insurance industry is playing a leadership role in society to counter climate change by interacting with other industries, establishing public policies and assisting developing countries, which is evident in best practices already exercised by leading insurance companies.

1. Introduction

As this report has studied thus far, climate change is considered as one of the most serious risks which could affect the whole socio-economic structure of any country in the world. Climate change has caused a rise in average temperatures, localized torrential rain, drought and water shortages in various parts of the world. These phenomena have caused not only damages to property but have also led to economic losses, such as the deprivation of income opportunities, which are all as a result of natural disasters. Furthermore, climate change will also have a serious impact on human life, health, the ecosystem and biodiversity, which also needs to be considered. Under these circumstances, the insurance industry needs to recognise climate change as a threat which will severely influence the entire socio-economy of the world.

The insurance industry, which is committed to promoting an affluent comfortable society and economic development, needs to fulfil its mission to offer customers high quality products and services through providing safety and security without disruption as the risk of climate change increases in the future. To stay committed to its responsibility, the insurance industry needs to:

- further refine risk analysis and assessment techniques,
- apply appropriate terms and conditions to insurance,
- develop new products and services to cope with emerging risks,
- continue with its efforts to promote reliable claim services,
- reinforce the consulting function on loss prevention and reduction, and
- share its knowledge and expertise with society.

In addition, insurance companies, as institutional investors, are able to contribute to society in various ways. Promoting mitigation efforts through investing in or financing clean energy projects is a viable activity. The insurance industry may reduce the stress level on the environment through improving its business operations. It can actively engage in establishing public policies, and play an active role in transferring the relevant knowledge to developing countries.

This chapter focuses on the key roles of the insurance industry in taking measures against climate change, through highlighting best practices of the insurance industry.

2. Leadership in risk research—understanding the climate change impact

In the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) which was released after February 2007, it is pointed out that climate change caused by global warming may increase the trend of and projections for extreme weather events in the long term. In order to analyse the likely effects of increasing extreme weather events on natural disasters, the insurance industry has conducted research taking into account actuarial analysis, statistics and engineering. Furthermore, the industry is undertaking new types of physical modelling approaches such as meteorology, with the cooperation of experts and academics.

Some insurance companies best practices:

- ***Allianz*** has funded studies on climate change and works with the World Wide Fund For Nature (WWF) in carrying out research into climate change. One

of the main goals of collaboration is to precisely quantify both the direct and indirect effects of climate change.[131]

- ***Munich Re*** has collaborated with Professor Nicholas Stern and the London School of Economics and Political Science, and launched The Centre for Climate Change Economics and Policy to lead research on climate change economics and policy.
- ***Tokio Marine & Nichido*** has recently formed the Global Warming Research Group in its research institute, and also with academic organisations such as the University of Tokyo and Nagoya University. Tokio Marine & Nichido Fire has been carrying out research into the effects of climate change on natural disasters.[132]

2.1 Leadership in insurance products and services

In response to changes in social conditions and lifestyles, insurance products have developed and improved. Currently, since climate change is considered as the most threatening risk in the future, the insurance industry is now developing products relative to climate change and natural catastrophic risks, as an adaptation measure. Focus is also given to products which incentivize offsetting or reducing greenhouse gas emission.

Automobile insurance

Automobile insurance is one of the most familiar insurance products in our daily lives. While minimising the level of greenhouse gas emission, eco-friendly automobile insurance plays an important role as an incentive for consumers to become conscious about environmental protection, for instance through providing premium discounts. Insurance companies are focusing on the development of eco-friendly insurance products from various aspects of automobile insurance such as fuel economy, insurance premiums based on driving distance, and environmentally benign repairing procedures.

Some insurance companies best practices:

- ***Allianz*** offers reduced insurance premiums for customers that insure low-emission vehicles and also offers products that customers can elect to offset the emissions of their cars when purchasing insurance.[133]
- ***Progressive*** offers lower automobile insurance rate on vehicles that are driven in less risky ways. A small wireless device that plugs into the port in the car allows the company to see how much and when the car is being driven. Cars driven less often, in less risky ways can achieve a lower premium causing customer behavioural changes leading to savings.[134]

Other property and casualty insurance

The insurance industry is developing various insurance products besides automobile insurance in an effort to reduce greenhouse gas emission within society.

Some insurance companies best practices:

- ***Fireman's Fund*** offers insurance products for buildings which encourage replacing standard systems and materials with specified green alternatives such

[131] Allianz (2007, 2008).
[132] Tokio Marine & Nichido Fire (2007a and b).
[133] Allianz 'Sustainable Products and Services'.
[134] Progressive (2008).

as non-toxic paints and carpeting, energy-efficient lighting systems and water efficient interior plumbing.[135]

- U.K.-based ***Naturesave*** (underwritten at Lloyd's of London) offers free environmental performance reviews to demonstrate ways in which a company/organisation can adopt more environmentally conscious trading practices and provides practical advice towards more energy efficient operational activities.[136]
- In partnership with other insurance groups, ***AXA*** offers carbon offset insurance policies. The system estimates the CO_2 produced by the insured vehicle or the air travel involved in the insured trip, and then enables customers to purchase travel or motor insurance products effectively offsetting the related CO_2 emissions.[137]
- ***Lockton Risk Services*** has developed a package of professional liability, general liability and property coverage for professional home energy auditors.[138]

2.2 Alternative energy project insurance and encouraging eco-friendly technology

Alternative energy development projects and eco-friendly technologies are gaining popularity in many parts of the world with the introduction of solar power, geothermal energy and wind power generation systems in place of classic systems dependent on fossil fuel. It is becoming essential for insurance companies to develop insurance products and derivatives to support those projects. Alternative energy business may attract further investment with the help of insurance products and derivatives. Therefore, it becomes critically important for the insurance industry to underwrite risks properly and help sustain the said business.

Some insurance companies best practices:

- In Germany, ***AXA*** has developed a comprehensive insurance package for wind farms that covers the setting up of the farms, machine breakage, civil liability and other related elements of cover.[139]
- ***Insurance companies in China*** have been working to encourage all industries to use technology that meets environmental standards in cooperation with State Environmental Protection Administration (SEPA), by providing premium discounts for enterprises which adopt eco-friendly technologies while suggesting premium increases for those which do not.[140]
- ***Sompo Japan*** has worked with home solar power system manufacturers to develop systems with weather compensation attached in the form of a derivative that compensates consumers who have installed a solar power system, in the event of abnormal weather conditions resulting in lower than normal hours of sunlight. This product is expected to help promote sales of home solar power systems.[141]

[135] Fireman's Fund website.
[136] ABI (2007).
[137] AXA website.
[138] Mills (2007).
[139] AXA '*Response to the Draft Climate Change Bill*'.
[140] Private communication from China Insurance Regulatory Commission.
[141] Sompo Japan (2007).

3. Leadership in loss prevention/consulting

Understanding the nature and magnitude of damages and risks of natural disasters triggered by climate change in advance is extremely effective in minimising the impact of a disaster. With the heightened public awareness, the insurance industry is working on improving loss prevention and technology development relative to natural disaster risks from their experience and expertise acquired over the past years. The industry is making the most of the outcome to prevent losses for customers and the general public.

Some insurance companies best practices:

- U.K.-based ***Norwich Union (Aviva)*** has launched the digital flood map in the U.K. which leads to deepening people's understanding on the risks of their properties. The company has also developed the flood-resilient model home, which is projected to dramatically reduce the average cost of a flood claim through flood proofing and flood alarm systems.[142]
- ***IAG (Insurance Australia Group)*** developed a partnership with local government planners in New Zealand to determine the most appropriate flood planning levels for the future. IAG provided results indicating changes in extreme rainfall, which the local government then used to determine the likely changes to future flood levels. This was then incorporated into its flood mitigation programme, e.g. planning for higher levee banks.[143]
- ***Lloyd's*** has launched a website to inform customers of hurricane risks and provide advice on how to prepare for a hurricane, as well as provide weather news headlines from Dow Jones.[144]
- ***Munich Re*** has developed Globe of Natural Hazards, which enables its users to easily grasp natural hazards and climate effects and evaluate natural-hazard risks from a geo-scientific perspective.
- ***Swiss Re*** has developed CatNet™, the online natural hazard information and mapping system, in order for clients to assess natural hazard exposure for any location worldwide.

4. Leadership in investment and finance

Many insurance companies are investing in and financing clean energy projects and offer eco-friendly funds. In this way, the insurance industry, as a major institutional investor, supports preventive efforts against climate change from a financial perspective.

Some insurance companies best practices:

- In April 2007, ***Swiss Re*** announced the close of the Euro 329 million (US$443m) European Clean Energy Fund, one of the largest funds of its type in Europe.[145]
- ***Mitsui Sumitomo*** offers an eco-friendly investment trust product that invests in selected companies that have high environmental awareness and engage in eco-friendly projects. In assessing the companies' environmental projects, Mitsui Sumitomo also focuses on their preventive measures against global warming.[146]

[142] Norwich Union website, and Aviva (2006).
[143] Mills (2007).
[144] Lloyd's website.
[145] Mills (2007).
[146] MSIG website.

- As early as 2002, ***Munich Re*** decided that their investments in shares and corporate bonds had to meet certain sustainability requirements and these were extended to government bonds at the end of 2005. The target is for 80 per cent of those investments to satisfy their sustainability criteria. The company apply generally recognised criteria such as the Dow Jones Sustainability Index and sustainability ratings issued by respected research agencies.[147]

5. Leadership in reduction of the environmental load resulting from own business activities

Every corporate entity is expected to make utmost efforts to reduce greenhouse gases, such as carbon dioxide, which causes global warming. The insurance industry consumes huge amount of paper and electricity, hence further resource and energy- saving measures are necessary to reduce the level of consumption. A good number of insurance companies are working aggressively to lighten the environmental burden of their activities as a mitigation measure.

Some insurance companies best practices:

- ***Aviva*** requires all suppliers to sign the Aviva Supplier Code of Conduct. The Code covered more than £1.1 billion of their procurement activity during 2007. Aviva's top 200 suppliers are assessed against a series of questions designed to measure their commitment to corporate social responsibility (CSR), and each Aviva business must establish a CSR performance improvement plan for its top five suppliers.[148]
- ***TrygVesta*** has set a target of 10 per cent reduction of CO_2 emissions in the period 2008-2010 and has adopted a new and more climate-friendly policy for company cars. Also a learning programme about climate change has been implemented for all of their employees in the spring of 2008.[149]
- As of the end of fiscal year 2007, ***Tokio Marine & Nichido*** became a "carbon neutral" company through utilisation of renewable energy and emissions trading, as well as the mangrove reforestation project that started in 1999. With its more than 5,500 hectares of mangroves already in place in six countries in South-East Asia and South Pacific, the company has made a commitment to continue to undertake the project for another 100 years into the 22nd century. Fully utilising this project, Tokio Marine Group as a whole is also targeting carbon-neutrality on a global basis by the end of 2011.[150]

6. Leadership in participating in the formulation of public policy

Public policies affect the insurance industry in various dimensions. The same holds true for climate change issues where wide-ranging discussions are held such as the establishment of natural catastrophe pools, development of improved building codes,

[147] Munich Re website.
[148] ClimateWise (2007).
[149] TrygVesta (2008).
[150] Tokio Marine & Nichido Fire (2008).

greenhouse gas emission regulation including automobile fuel-economy standards, and creation of emission trading markets. The insurance industry is actively involved in environmental policy-making both nationally and internationally. The industry makes policy proposals as a financial industry as well as on its own through participation in, for instance, international organisations and environmental groups.

Some insurance companies best practices:

- Many companies from the insurance industry are signatories to the ***United Nations Environment Programme Finance Initiative (UNEP FI)***. UNEP FI carries out its mission to identify, promote and realise the adoption of best environmental and sustainability practices at all levels of financial institution operations, and the Initiative continues to receive government recognition for its work via the United Nations Framework Convention on Climate Change.[151]
- Over 40 leading companies and organisations in the insurance industry signed up to the ***ClimateWise*** Principles, which commit to taking action to reduce the risk of climate change, including informing and engaging in public policy debate.[152]
- Insurance broker Marsh has joined the ***United States Climate Action Partnership (USCAP)***. USCAP is an expanding alliance of major businesses and leading climate and environmental groups that have come together to call on the federal government to enact legislation requiring significant reductions of greenhouse gas emissions.[153]

7. Leadership in transferring insurance expertise to emerging/developing countries

Those who are most severely impacted by climate change tend to be emerging or developing countries. For example, according to the Intergovernmental Panel on Climate Change (IPCC), increasing droughts and floods are expected to have more serious effects than ever on people's lives in many African and Asian countries where agriculture is an economic backbone. However, disaster-prone countries often lack financial infrastructure such as risk transfer and insurance systems. It is, therefore, essential to transfer the insurance expertise of the industrialised countries to the emerging/developing economies and many insurance companies offer innovative products such as micro-insurance to protect low-income people against extreme weather events.

Some insurance companies best practices:

- In 2007, ***Swiss Re*** announced the launch of its Climate Adaptation Development Programme which is designed to help develop a financial risk transfer market to handle the effects of adverse weather in non-OECD countries. Under this programme, the company partners with local insurers, banks, governmental and non-governmental organisations and others to design risk transfer solutions that help lift smallholder farmers out of the poverty trap.[154]

[151] UNEP FI website.
[152] ClimateWise website.
[153] USCAP website.
[154] Swiss Re (2008).

- In February 2007, ***Zurich Financial Services*** signed a public private partnership with the Swiss Agency for Development and Cooperation and the International Labour Union to provide technical assistance to micro-insurance projects in Bolivia, South Africa and Venezuela.[155]
- ***Munich Re*** has been working with the World Bank and London broker Benfield and was closely involved in the Caribbean Catastrophe Risk Insurance Facility (CCRIF) coverage concept from the outset. CCRIF offers Caribbean island States insurance cover against hurricanes and earthquakes, thus enabling the relevant countries to overcome a liquidity crunch following a disaster.[156]

8. Epilogue

Some may say that the priority issue the insurance industry should work on is the financial crisis and the economic recession, before climate change. However, in the opening of the United Nations Climate Change Conference, Polish Prime Minister Donald Tusk said "*Scientists share the view that warming in excess of 2°C will result in irreversible changes to nearly all ecosystems and human communities. We shoulder the responsibility to prevent changes that could lastingly disturb the symbiosis between humankind and nature*." As Mr. Tusk pointed out, the need for progress in climate change reactive measures is a fundamental challenge that human beings must work on together and the insurance industry is expected to continue working on this issue in the long term. There is no doubt that delaying this work will worsen the harmful effect of climate change.

Examples in this chapter are just a part of the efforts carried out in the insurance industry. While there are many insurers who are devoted to combating the climate change issues, it is also true that some are still reluctant to take action. Without any doubt, the insurance industry should play a major role in the global efforts to address climate change by following best practices as laid out in this chapter.

As stated earlier, the insurance industry can exert an immeasurably strong influence on a wide variety of areas by interacting with other industries, establishing public policies and assisting developing countries. Its approach may even influence various stakeholders including customers and investors. The insurance industry should keep its commitment to address the climate change impact on the entire human socio-economy and eco-system in the long term. Thus it should be able to contribute to the sustainable development of society by achieving harmonious coexistence with the global environment.

[155] Zurich (2007).
[156] Munich Re (2007).

Conclusions

Climate change is all about risk, and since the insurance industry is in the business of managing risk, it needs to think about the greatest risks for the world population.

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President and CEO, PZU S.A., Poland

Climate change issues are a priority because they affect the future and the survival of our children.

Dr Rui Leão Martinho,
President, Companhia de Seguros Tranquilidade, Portugal

1. The case for a proactive strategy for the insurance industry

Climate change brings new risks but also new opportunities for the insurance sector. These differ between industrial countries and developing countries. A proactive approach has to be based on a vision of the future that can be used in forward-looking and back-casting methods, in order to open paths to move towards this vision. There is increasing evidence that a low-carbon economy could be such a common vision especially for industrialised countries, which are the major insurance markets.

But as industrial economies coupled with a consumer society cannot be low-carbon, a transition to a more sustainable economy is inevitable to reach a low-carbon future. The transition to these low-carbon approaches will change risks and opportunities for the insurance industry, as well as its relationship with the economic actors involved. Climate change is a moving target. Many industrial clients have started to adapt their corporate strategies to more sustainable business models, and many insurers will adapt their products. Homing in on a proactive climate change strategy will enable the insurance industry to stay ahead and above expected climate change events. It can use its strong potential, for instance, to guide customers and suppliers in claims-handling towards more climate-friendly and weather-proof alternatives.

Regarding developing countries, adaptation needs depend on the specific risk landscape of a region or country. Insurance has an important contribution to make in this area, particularly because of the industry's experience in assessing and pricing risk. Although at the moment only few and often small-scale piloting solutions have been implemented in developing countries, the insurance sector is uniquely positioned to provide necessary services for countries and business facing climate risks in the developing world.

In all markets, integrated risk assessment will help ensure prudent investments in well-designed adaptation measures suitable for addressing local climate risks. From an insurance perspective, specific weather-related hazards will need to be identified, quantified and prioritised on a local level.

The insurance industry should not only respond to the changed environment, but also be forward-looking in its behaviour, extending the scope of a management traditionally based on economic value. The motivation behind this proactive approach would be improved competitiveness and access to new business opportunities.

2. The issue of climate change

2.1 Science and politics

There is a consensus between science and politics that climate change has been happening and can be measured. Rises in average temperatures and in average sea levels are some of the changes caused by climate change that might severely impact the world economy and economics of insurance.

There is also agreement that it makes sense to mitigate climate change by reducing the man-made emission of greenhouse gases (GHGs) into the atmosphere. The activities of industrial economies have altered the abundance of GHGs and aerosols in the atmosphere,

mainly through the burning of fossil fuels. Together with the changed properties of land use, this has contributed to changes in climate.

The economic and social impacts of climate change could be immense; there is therefore a need for urgent and concerted *mitigation* action to reduce GHG emissions, supported by strong incentives from policy-makers. But regardless of the action taken to mitigate climate change, we can expect many decades of changing climate risks due to inertia within the climate system. We therefore also need concerted *adaptation* to avoid the predicted impacts of climate change and especially to protect the most vulnerable populations.

2.2 A multitude of societal players

Global weather-related insured loss experience since 1990 shows a clear upward trend. Reasons for this trend are largely socio-economic factors, such as economic growth, increasing population densities and insurance penetration. Value concentrations in coastal areas and increasing vulnerabilities of insured values also contribute to rising weather-related losses worldwide. In the record hurricane year of 2005, insured weather-related losses averaged approximately US$100bn due to major events such as hurricanes Katrina, Rita and Wilma, according to Munich Re.[157] These insured losses stem only from "great disasters" and may be less than half of the total insured losses worldwide— a classic risk/loss iceberg, where most losses are invisible to insurers (i.e. below the waterline).[158]

The insurance sector and society as a whole thus face a dual challenge and opportunity. First, most of the factors related to increasing losses are not climate-related, but societal in origin, thus increasing the need for effective and integrated risk management and risk reduction.[159] Risk reduction efforts, if effective, can help maintain insurability as the proportion of risk attributable to climate change, rises over time. Second, there is a need and a market niche to develop insurance solutions for areas facing increasingly frequent and intense weather-related hazards.[160]

Both mitigation and adaptation efforts on the impact of climate change are necessary to limit the economic losses and natural disasters that are predicted as a result of climate change. These actions can be taken by politicians, economic actors and individuals. As concerted actions will increase the efficiency of these measures, it is crucial that methods of adaptation and mitigation work in parallel and are used together, and that incentives are developed to speed up both approaches.

Traditionally, concrete actions have been driven by general political objectives, such as the 1992 Kyoto Agreement by governments to limit national GHG emissions over a period of 20 years. But increasingly, politics will aim directly at businesses on a regional level. The recent decision by U.S. State insurance regulators that insurance companies must start disclosing how climate change is likely to affect their businesses is just one example.[161]

The alternative is for economic actors to become proactive. This opportunity is open to insurance as an industry, as well as to individual insurance companies. A

[157] Munich Re (2007).
[158] See Dlugolecki (2007).
[159] Ward *et al*. (2008), Maynard (2008).
[160] Dlugolecki *et al.*(2009), Mills (2007).
[161] See for instance *The Wall Street Journal* (2009).

proactive approach is reinforced by partnerships with clients, other economic actors and authorities.

3. Climate change challenges and opportunities

3.1 Climate change challenges and opportunities for the world

Unmitigated climate change is likely to have significant adverse effects on physical, biological and human systems. A business-as-usual scenario on a world level cannot ignore the threat that millions of people in developing countries could be deprived of the basic necessities of life, such as land, food and clean water. This could lead to social disorder, mass migration, commodity price effects and insecurity, an evolution that would clearly undermine economic stability and insurability.

Unmitigated climate change may also have significant adverse effects on the long-term development of the world economy. Water shortages for food production, rising sea levels for coastal and port areas, and major natural catastrophes may reach 1 per cent of GDP in industrialised countries (like Hurricane Katrina in the U.S. in 2005), but much higher figures in developing countries (a 1999 drought cost 16 per cent of Kenya's GDP). Parts of these losses are caused by socio-economic factors or natural climatic variations. It is still unclear what proportion of climate change can be attributed to anthropogenic global warming, And in many regions, the impacts of climate change on the national economy may become increasingly negative with rising global temperatures.

The cost of *mitigation* is estimated at between 0 and 4 per cent of GDP. Mitigation options can be shared globally, and some actually save money in net present value terms, led by higher energy efficiency and low-carbon technologies. Geo-thermal power is the only technology producing a reliable flow of energy which is uncorrelated with weather and daylight and has little environmental impact as most of the infrastructure is below ground. Tidal and nuclear power shares many of these advantages, while solar energy and wind farms need rapid back-up infrastructures (typically gas turbines). Incentives for mitigation can be provided through taxation and regulated emission cap and trade.

Regardless of the actions taken to mitigate climate change, we can expect many decades of climate change risks due to inertia within the climate system. Therefore the world must also *adapt* to the predicted impact of climate change. Developing countries may have a higher vulnerability to climate change, arising mostly from geographical exposure, such as large populations living in coastal areas, or from lower economic diversification. And developing economies tend to have a greater proportion of output which is sensitive to weather or climate. Adaptation measures will differ regionally or locally, depending on agricultural traditions, water availability, construction techniques and quality of life issues, such as health.

3.2 Climate change challenges and opportunities for the insurance industry

The insurance industry has been feeling the impacts of climatic change for many years in its loss experience. The potential effects of (anthropogenic) climate change on insured property losses were anticipated as early as 1973, when it was stated in a brochure on flood/inundation:

> "*Investigations into the overall trend of claims experience are indispensable, and here climatic variations become most significant. Such investigations involve a study of thermodynamic processes such as, for example, the rising temperature of the earth's atmosphere (as a result of which glaciers and the polar caps recede ...). ... We wish to enlarge on this complex of problems in greater detail, especially as ... its conceivable impact on the long-range risk trend has hardly been examined to date.*"[162]

In 1979, the Fire & Marine Insurance Rating Association of Japan released the publication *Research of Disaster*, Vol. 10 which contains an article "Future of the environmental carrying capacity, from the climate change perspective" by Masatoshi Yoshino. The author warns that:

> "*There is a prediction that, in the 21st Century, we will have a remarkable high temperature that has not been experienced in the past 1000 years.*"

Today there are several approaches for adapting to the growing climate change risk. Risk-adequate pricing on the basis of science-based loss models and methodologies is fundamental. Additional measures include restricting coverage, applying deductibles, improving claims-handling, reinsurance, insurance-linked securities which transfer risks to capital markets, public-private action on improving building codes and flood defences. New insurance products in the context of mitigating GHG emissions and adapting to climate change impacts are going to be developed, such as micro-insurance schemes in developing countries. On the assets side, risks and opportunities for specific sectors which might arise from changes in the physical environment, as well as through regulatory policy, are increasingly being considered in investment decisions.

If risks from natural hazards were rising under (anthropogenic) climate change, the insurance industry most likely would expand in terms of the volume of premiums written, claims paid and income from the assumption of risk-adequate pricing procedures and prospective underwriting.[163] The bottom line is that insurance products are crucial for worldwide societal transformations into hazard-adaptive societies which support GHG emissions' reduction through development and deployment of low-carbon and energy-efficient technologies.

The insurance industry can contribute in many ways to this transition but may have to redefine its role. In some areas, even the historical role of the insurance industry as provider of financial protection may change. Some insurers feel that insurance should provide peace of mind for families and encourage businesses to thrive. Governments and the insurance industry clearly have a common objective to plan for overall sustainable economic growth, wealth and welfare, and therefore to take into account the need for stronger climate cooperation.

But insurers are also the risk experts. The losses in value and productive capacity in developing countries may rise, and the need for risk management tools such as insurance is growing in these areas at a time when climate-related and other risks are also rising. But it is important that the framework for insurance be established in ways that allow healthy market growth after future agreements are sketched out, for instance December 2009 in Copenhagen. Such agreements need to establish the framework—especially within

[162] Munich Re (1973) *Flood/Inundation*, Munich, 1 August 1973.
[163] IPCC (2007), Ch.7 Industry, settlement and society, p. 369.

risk management—for risk transfer mechanisms to work appropriately and incentivize vulnerability reduction for the poor. The insurance sector has a vital role to play in sharing examples and lessons about how these tools can help improve the resilience of low-income households to climate-related risks.

In addition, insurance companies, as institutional investors, are able to contribute to society in various ways. Promoting mitigation efforts through investing or financing clean energy projects is a viable activity. They may also reduce the stress level on the environment through improving their operational activities, such as real estate and IT centres. They can actively engage themselves in establishing public policies, and play an active role in transferring our relevant knowledge to developing countries.

The insurance industry can exert an immeasurably strong influence on a wide variety of areas by interacting with other industries, establishing public policies, and assisting developing countries. Its approach may even influence various stakeholders including customers and investors. By focusing on its commitment to address the climate change impact on the entire human socio-economy and ecosystem in the long term, the insurance industry is able to contribute to the development of a sustainable society.

4. The economic impact of climate change on insurance

To give a feeling for the scale of the effect that insurers might expect climate change to have upon their Maximum Possible Loss (MPL), the 2009 Chartered Insurance study[164] suggests two rough estimates for flood and storm risks. Without climate change adaptation, it suggest that the peak value could be 50 per cent greater for floods and 30 per cent greater for storms. These are for general guidance only, and the actual factors could vary considerably. They reflect several factors: climate change is already happening, rainfall is becoming more intense, storms are wetter due to the fact that warm air carries more moisture, drainage systems are at capacity, and emergency and construction services are also under-resourced.

A low-carbon economy is driven by politics (e.g. the Eco-Model Cities initiative by the Japanese government, the U.K.'s initiative tackling climate change)[165] and will become reality in the medium-term future. But the transition to a low-carbon economy will already provoke fundamental changes in the economic structure. And it will change the rules of the game for many economic actors and thus the insurance industry. The transition to a low-carbon economy changes the incentive structure for economic actors, the risks and opportunities for the insurance industry, as well as the relationship between insurance and the economic actors involved. Insurers could also provide training courses for enterprises to raise awareness of hazards caused by climate change facts, and to teach solutions for loss prevention.

The insurance industry has a clear strategic and economic interest in addressing the problems of climate change for society, households and businesses. The industry must be equally committed to help with emerging and changing climate risks and help identifying

[164] Dlugolecki (2009).

[165] See for instance CCC (2008) or The Japanese Government's Panel (2008) on a low-carbon society to discuss global warming and 'Eco-Model Cities'.

appropriate responses and adaptations. Insurance is widely acknowledged in society as a serious risk advisor to businesses and individuals, a role that can be further developed into a natural leadership in tackling the emerging and growing climate risks to society. But a precondition for private markets to function is timely, well-informed and efficient adaptation decisions.[166]

5. The opportunity for climate partnerships between the insurance industry and governments

A stronger climate partnership between the insurance industry and governments can generate considerable new potential to help society, businesses and households counter the emerging climate risk in future. But robust national plans for adaptation are necessary preconditions for the insurance industry to play an active climate role in the future, together with governments. If the economy, businesses and households are not prepared for greenhouse gas reductions adjusted to the coming climate change, insurance as we know it today will be more expensive and in some cases and areas may no longer be economically feasible.

New, innovative insurance instruments can play an important role to help bridge some of the adaptation financing gap by helping to reduce the costs associated with climate extremes and transferring those risks through insurance mechanisms where they can be reduced efficiently.[167] They can be applied on a macro-level, for instance as catastrophe bonds (cat bonds) to tap into capital markets to help fund the cost of recovery on a national and international level, or they can be applied on the micro-level, for instance as index-based weather risk transfer instruments, to cover weather-related risks for the agricultural sector. Micro-insurance products can be embedded into micro-credit products, thereby greatly facilitating access to financing for individual farmers, reducing poverty traps, and increasing resilience to shocks.[168]

Governments could more actively support a more climate sustainable claims-handling process through the regulatory framework or/and the right economic incentive structure, especially in the sectors of industrialised countries which are of high relevance on the climate agenda.

In developing countries, however, insurance penetration remains very low. Yet some initial, innovative public private initiatives undertaken by the World Bank, international donors, and some (re)insurance companies demonstrate a potential to pool the management of weather variability and climate extremes, and transfer risks to the global capital markets. Countries such as Ethiopia are also using insurance-related mechanisms, such as an index-based drought insurance scheme for government relief expenditure. Future transactions may include a catastrophe bond, which pays an above-market interest rate if rainfall exceeds a specified level, but where the principal goes partly to the Ethiopian government if rainfall is below this level.

The Kyoto Protocol will end in 2012. For the inclusion of insurance instruments in the post-2012 adaptation regime, the potential role of financial risk-transfer systems must

[166] OECD (2008).
[167] Bouwer *et al.*(2007), Höppe and Gurenko (2006), Kunreuther (2006), Benson and Twigg (2004).
[168] Barnett *et al.*(2008), Cohen and Sebstad (2003).

be firmly established. The emerging negotiating text suggests that an insurance component should (1) follow the principles set out by the United Nations Framework Convention on Climate Change (UNFCCC) for financing and disbursing adaptation funds, (2) help those countries particularly vulnerable to the impacts of climate change, and (3) include private market participation. Before Copenhagen, the Parties will design the overall architecture of a post-2012 climate agreement, with insurance solutions contributing tangibly to the management of climate risks and climate change adaptation.

6. Going forward

The insurance industry is currently going from a reactive approach to a proactive one. It is moving from being a passive climate change sufferer that has to sustain some very expensive consequences to becoming a proactive shaper of the future. Climate change represents arguably the greatest long-term challenge to the industry. The knowledge and expertise that insurance experts can inject into public debates and the solutions they can design will be necessary for humankind to overcome the climate challenges of the future. It is good news that the leaders of the world's largest insurance companies, as represented in The Geneva Association, have identified climate change as their joint long-term priority number one. This report is a major step forward in putting insurance competency together from all over the world, and a starting point for making it available to societies everywhere.

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Glossary

anthropogenic	originating in human activity
aquifer	a body of rock that holds water or through which water flows
autarky	an economically independent state or society
biosphere	the regions of the surface and atmosphere of the earth occupied by living organisms
CAT-swap	in a catastrophe swap, an insurer agrees to make periodic payments to another party, and the other party agrees to make payments to the insurer which are based on a measure of catastrophe losses
cryosphere	the domain of snow and ice
forcing	a process that alters the energy balance of the climate system
halocarbons	halocarbon compounds are chemicals in which one or more carbon atoms are linked by covalent bonds with one or more halogen atoms (fluorine, chlorine, bromine or iodine)
hydrosphere	the seas, lakes and other waters of the earth's surface, considered collectively
meridional	of or relating to a meridian
photovoltaic	relating to the production of electric current at the junction of two substances exposed to light
quaternary	*(Geology)* relating to the most recent period in the Cenozoic era
Risk Loss Iceberg	an image which illustrates that in most disasters, the insured losses (the visible part) are only a small portion of the total economic losses (the invisible part)
stochastic	having a random probability distribution or pattern that can be analysed statistically but not predicted precisely
thermohaline	of, or relating to a combination of temperature and salinity
troposphere	the lowest region of the atmosphere, extending from the earth's surface to a height of about 6-10 km (the lower boundary of the stratosphere)
wind shear	variation in wind velocity along a direction at right angles to the wind's direction, tending to exert a turning force

Source: Oxford English Dictionary, Wiktionary.

List of acronyms

ABI	Association of British Insurers
ACCE	Amsterdam Circle of Chief Economists
AMO	Atlantic Multidecadal Oscillation
AOSIS	Association of Small Island States
BAP	Bali Action Plan
BAT	Best Available Technology
BCSD	Business Council for Sustainable Development
CAN	Climate Adaptation Network
CCRIF	Caribbean Catastrophe Risk Insurance Facility
CDIAC	U.S. Department of Energy Carbon Dioxide Information and Analysis Center
CDM	Clean Development Mechanism
CDP	Carbon Disclosure Project
CNT	carbon-nanotubes
CDM	clean development mechanism
CCS	carbon capture and storage
COP	Conference of the Parties (UNFCCC)
CSR	corporate social responsibility
ENSO	*El Niño* Southern Oscillation
ERI	Emerging Risk Initiative
ETS	Emissions Trading Scheme
FAO	Food and Agriculture Organization of the United Nations
FFSA	Fédération Française des Sociétés d'Assurance
GDP	gross domestic product
GEF	Global Environment Facility (GEF)
GHG	greenhouse gas
IBRD	International Bank for Reconstruction and Development
IEA	International Energy Agency
III	Insurance Information Institute
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
IPCC AR4	Fourth Assessment Report of the IPCC

ISDR	International Strategy for Disaster Reduction
JI	Joint Implementation
LCA	life cycle analysis
LDCs	least developed countries
LDCF	Least Developed Countries Fund
MCII	Munich Climate Insurance Initiative
MDGs	Millennium Development Goals
MJO	Madden-Julian Oscillation
MMC	Multihazard Mitigation Council
MPL	Maximum Possible Loss
NAO	North Atlantic Oscillation
NAPAs	National Adaptation Programmes of Action
NGO	non-governmental organisation
OECD	Organisation for Economic Co-operation and Development
PDO	Pacific Decadal Oscillation
REO	Responsible Engagement Overlay
SCCF	Special Climate Change Fund
SLR	sea level rise
SRES	Special Report on Emission Scenarios (Intergovernmental Panel on Climate Change)
SRI	Socially Responsible Investment
SST	sea surface temperatures
UNEP	United Nations Environment Programme
UNEP FI	UNEP Finance Initiative
UNFCCC	United Nations Framework Convention on Climate Change
UN/ISDR	United Nations International Strategy for Disaster Reduction
USCAP	United States Climate Action Partnership
WHO	World Health Organization
WMO	World Meteorological Organization
WRI	World Resources Institute

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ISSN 1662-3738