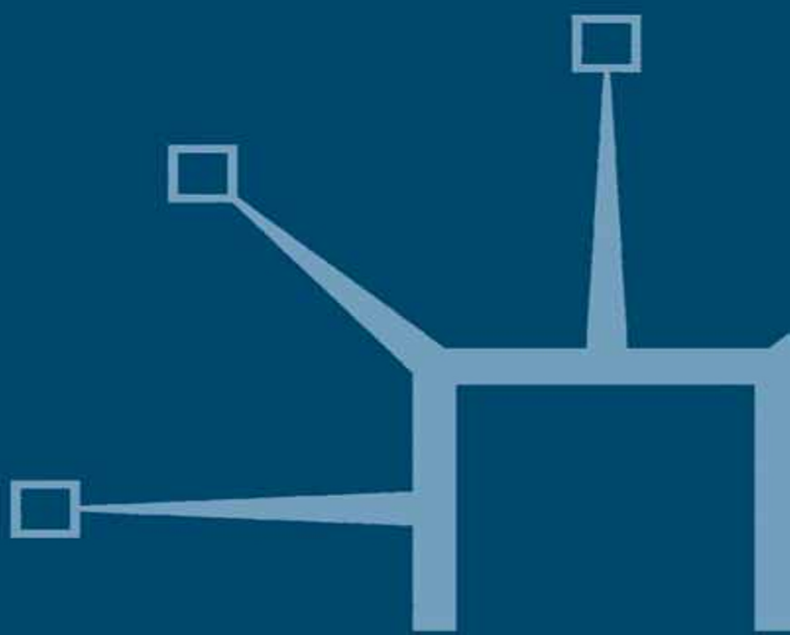
palgrave
macmillan

Human Development Report 2007/2008

United Nations Development Programme



Human Development Report **2007/2008**

Fighting climate change:
Human solidarity in a divided world

Published for the
United Nations
Development
Programme
(UNDP)

ISBN 978-0-230-54704-9 ISBN 978-0-230-59850-8 (eBook)
DOI 10.1057/9780230598508

First Published in 2007 by
Palgrave Macmillan
Houndmills, Basingstoke, Hampshire RG21 6XS and
175 Fifth Avenue, New York, NY 10010

Companies and representatives throughout the world.

Palgrave Macmillan is the global academic imprint of the Palgrave Macmillan division of
St. Martin's Press, LLC and of Palgrave Macmillan Ltd.

Macmillan is a registered trademark in the United States, United Kingdom, and other countries.
Palgrave is a registered trademark in the European Union and other countries.

10 9 8 7 6 5 4 3 2 1
Printed in the U.S.A. by RR Donnelley/Hoechstetter (Pittsburgh). Cover is printed on International Paper's 15 pt Carolina
low-density coated-one-side paper that is chlorine free and meets the Sustainable Forest Initiative guidelines.
Text pages are printed on Cascades Mills' 60# Rolland Opaque30 Smooth text that is de-inked 30% post-industrial fibre,
Forest Stewardship Council certified and produced with Biogas energy. Both cover and text papers are printed with vegetable-based inks and
produced by means of environmentally-compatible technology.

Editing: Green Ink Inc.
Cover: talking-box
Information design: Mapping Worlds, Phoenix Design Aid and Zago
Layout: Phoenix Design Aid

For a list of any errors or omissions found subsequent to printing, please visit our
website at http://hdr.undp.org

Team for the preparation of Human Development Report 2007/2008

Director and lead author
Kevin Watkins

Research and statistics
Cecilia Ugaz (Deputy Director and chief editor), Liliana Carvajal, Daniel Coppard, Ricardo Fuentes Nieva, Amie Gaye, Wei Ha, Claes Johansson, Alison Kennedy (Chief of Statistics), Christopher Kuonqui, Isabel Medalho Pereira, Roshni Menon, Jonathan Morse and Papa Seck.

Production and translation
Carlotta Aiello and Marta Jaksona

Outreach and communications
Maritza Ascencios, Jean-Yves Hamel, Pedro Manuel Moreno and Marisol Sanjines (Head of Outreach)

The Human Development Report Office (HDRO): The Human Development Report is the product of a collective effort. Members of the National Human Development Report Unit (NHDR) provide detailed comments and advice throughout the research process. They also link the Report to a global research network in developing countries. The NHDR team comprises Sharmila Kurukulasuriya, Mary Ann Mwangi and Timothy Scott. The HDRO administrative team makes the office function and includes Oscar Bernal, Mamaye Gebretsadik, Melissa Hernandez and Fe Juarez-Shanahan. Operations are managed by Sarantuya Mend.

Foreword

What we do today about climate change has consequences that will last a century or more. The part of that change that is due to greenhouse gas emissions is not reversible in the foreseeable future. The heat trapping gases we send into the atmosphere in 2008 will stay there until 2108 and beyond. We are therefore making choices today that will affect our own lives, but even more so the lives of our children and grandchildren. This makes climate change different and more difficult than other policy challenges.

Climate change is now a scientifically established fact. The exact impact of greenhouse gas emission is not easy to forecast and there is a lot of uncertainty in the science when it comes to predictive capability. But we now know enough to recognize that there are large risks, potentially catastrophic ones, including the melting of ice-sheets on Greenland and the West Antarctic (which would place many countries under water) and changes in the course of the Gulf Stream that would bring about drastic climatic changes.

Prudence and care about the future of our children and their children requires that we act now. This is a form of insurance against possibly very large losses. The fact that we do not know the probability of such losses or their likely exact timing is not an argument for not taking insurance. We know the danger exists. We know the damage caused by greenhouse gas emissions is irreversible for a long time. We know it is growing with every day of inaction.

Even if we were living in a world where all people had the same standard of living and were impacted by climate change in the same way, we would still have to act. If the world were a single country, with its citizens all enjoying similar income levels and all exposed more or less to the same effects of climate change, the threat of global warming could still lead to substantial damage to human well-being and prosperity by the end of this century.

In reality, the world is a heterogeneous place: people have unequal incomes and wealth and climate change will affect regions very differently. This is, for us, the most compelling reason to act rapidly. Climate change is already starting to affect some of the poorest and most vulnerable communities around the world. A worldwide average 3° centigrade increase (compared to preindustrial temperatures) over the coming decades would result in a range of localized increases that could reach twice as high in some locations. The effect that increased droughts, extreme weather events, tropical storms and sea level rises will have on large parts of Africa, on many small island states and coastal zones will be inflicted in our lifetimes. In terms of aggregate world GDP, these short term effects may not be large. But for some of the world's poorest people, the consequences could be apocalyptic.

In the long run climate change is a massive threat to human development and in some places it is already undermining the international community's efforts to reduce extreme poverty.

Violent conflicts, insufficient resources, lack of coordination and weak policies continue to slow down development progress, particularly in Africa. Nonetheless in many countries there have been real advances. For instance, Viet Nam has been able to halve poverty and achieve universal primary education way ahead of the 2015 target. Mozambique has also managed to significantly reduce poverty and increase school enrollment as well as improving the rates of child and maternal mortality.

This development progress is increasingly going to be hindered by climate change. So we must see the fight against poverty and the fight against the effects of climate change as interrelated efforts. They must reinforce each other and success must be achieved on both fronts jointly. Success will have to involve a great deal of adaptation, because climate change is still going to affect the poorest countries significantly even if serious efforts to reduce emissions start immediately. Countries will need to develop their own adaptation plans but the international community will need to assist them.

Responding to that challenge and to the urgent request from leaders in developing countries, particularly in sub-Saharan Africa, UNEP and UNDP launched a partnership in Nairobi during the last climate convention in November 2006. The two agencies committed to provide assistance in reducing vulnerability and building the capacity of developing countries to more widely reap the benefits of the Clean Development Mechanism (CDM) in areas such as the development of cleaner and renewable energies, climate proofing and fuel-switching schemes.

This partnership, that will enable the UN system to act promptly in response to the needs of governments trying to factor in climate-change impacts into their investment decisions, constitutes a living proof of the United Nation's determination to 'deliver as One' on the climate change challenge. For example, we can help countries improve existing infrastructure to enable people to cope with increased flooding and more frequent and severe extreme weather events. More weather resistant crops could also be developed.

While we pursue adaptation we must start to reduce emissions and take other steps at mitigation so that the irreversible changes already underway are not further amplified over the next few decades. If mitigation does not start in earnest right now, the cost of adaptation twenty or thirty years from now will become prohibitive for the poorest countries.

Stabilizing greenhouse emissions to limit climate change is a worthwhile insurance strategy for the world as a whole, including the richest countries, and it is an essential part of our overall fight against poverty and for the Millennium Development Goals. This dual purpose of climate policies should make them a priority for leaders around the world.

But having established the need for limiting future climate change and for helping the most vulnerable adapt to what is unavoidable, one has to move on and identify the nature of the policies that will help us get the results we seek.

Several things can be said at the outset: First, non-marginal changes are needed, given the path the world is on. We need big changes and ambitious new policies.

Second, there will be significant short term costs. We have to invest in limiting climate change. There will be large net benefits over time, but at the beginning, like with every investment, we must be willing to incur the costs. This will be a challenge for democratic governance: political systems will have to agree to pay the early costs to reap the long term gains. Leadership will require looking beyond electoral cycles.

We are not too pessimistic. In the fight against the much higher inflation rates of the distant past, democracies did come up with the institutions such as more autonomous central banks and policy pre-commitments that allowed much lower inflation to be achieved despite the short term temptations of resorting to the printing press. The same has to happen with climate and the environment: societies will have to pre-commit and forego short term gratification for longer-term well being.

We would like to add that while the transition to climate protecting energy and life styles will have short term cost, there may be eco-

nomic benefits beyond what is achieved by stabilizing temperatures. These benefits are likely to be realized through Keynesian and Schumpeterian mechanisms with new incentives for massive investment stimulating overall demand and creative destruction leading to innovation and productivity jumps in a wide array of sectors. It is impossible to quantitatively predict how large these effects will be but taking them into account could lead to higher benefit-cost ratios for good climate policies.

The design of good policies will have to be mindful of the danger of excessive reliance on bureaucratic controls. While government leadership is going to be essential in correcting the huge externality that is climate change, markets and prices will have to be put to work, so that private sector decisions can lead more naturally to optimal investment and production decisions.

Carbon and carbon equivalent gases have to be priced so that using them reflects their true social cost. This should be the essence of mitigation policy. The world has spent decades getting rid of quantity restrictions in many domains, not least foreign trade. This is not the time to come back to a system of massive quotas and bureaucratic controls because of climate change. Emission targets and energy efficiency targets have an important role to play but it is the price system that has to make it easier to achieve our goals. This will require a much deeper dialogue between economists and climate scientists as well as environmentalists than what we have seen so far. We do hope that this Human Development Report will contribute to such a dialogue.

The most difficult policy challenges will relate to distribution. While there is potential catastrophic risk for everyone, the short and medium-term distribution of the costs and benefits will be far from uniform. The distributional challenge is made particularly difficult because those who have largely caused the problem—the rich countries—are not going to be those who suffer the most in the short term. It is the poorest who did not and still are not contributing significantly to green house gas emissions that are the most vulnerable. In between, many middle income countries are becoming significant emitters in aggregate terms—but they do not have the carbon debt to the world that the rich countries have accumulated and they are still low emitters in per capita terms. We must find an ethically and politically acceptable path that allows us to start—to move forward even if there remains much disagreement on the long term sharing of the burdens and benefits. We should not allow distributional disagreements to block the way forward just as we cannot afford to wait for full certainty on the exact path climate change is likely to take before we start acting. Here too we hope this Human Development Report will facilitate the debate and allow the journey to start.

Kemal Derviş
Administrator
United Nations Development Programme

Achim Steiner
Executive Director
United Nations Environment Programme

The analysis and policy recommendations of the Report do not necessarily reflect the views of the United Nations Development Programme, its Executive Board or its Member States. The Report is an independent publication commissioned by UNDP. It is the fruit of a collaborative effort by a team of eminent consultants and advisers and the Human Development Report team. Kevin Watkins, Director of the Human Development Report Office, led the effort.

Acknowledgements

This Report could not have been prepared without the generous contribution of the many individuals and organizations listed below. Special mention must be made of Malte Meinshausen of the Potsdam Institute for Climate Impact Research, who provided constant and patient advice on a wide range of technical issues. Many other individuals contributed to the Report either directly through background papers, comments on draft text, and discussions, or indirectly through their research. The authors wish also to acknowledge their debt to the fourth assessment of the International Panel on Climate Change, which provides an unrivalled source of scientific evidence, and to the work of Sir Nicholas Stern and the team behind his Report on *The Economics of Climate Change*. Many colleagues in the United Nations system were extremely generous in sharing their time, expertise and ideas. The Human Development Report team received helpful advice from the UNDP Administrator, Kemal Derviş. We thank all of those involved directly or indirectly in guiding our efforts, while acknowledging sole responsibility for errors of commission and omission.

Contributors

Background studies, papers and notes were prepared on a wide range of thematic issues relating to the Report. Contributors were: Anu Adhikari, Mozaharul Alam, Sarder Shafiqul Alam, Juan Carlos Arredondo Brun, Vicki Arroyo, Albertina Bambaige, Romina Bandura, Terry Barker, Philip Beauvais, Suruchi Bhadwal, Preety Bhandari, Isobel Birch, Maxwell Boykoff, Karen O'Brien, Oli Brown, Odón de Buen, Peter Chaudhry, Pedro Conceição, Pilar Cornejo, Caridad Canales Dávila, Simon D. Donner, Lin Erda, Alejandro de la Fuente, Richard Grahn, Michael Grimm, Kenneth Harttgen, Dieter Helm, Caspar Henderson, Mario Herrero, Saleemul Huq, Ninh Nguyen Huu, Joseph D. Intsiful, Katie Jenkins, Richard Jones, Ulka Kelkar, Stephan Klasen, Arnoldo Matus Kramer, Kishan Khoday, Roman Krznaric, Robin Leichenko, Anthony Leiserowitz, Junfeng Li, Yan Li, Yue Li, Peter Linguiti, Gordon MacKerron, Andrew Marquard, Ritu Mathur, Malte Meinshausen, Mark Misselhorn, Sreeja Nair, Peter Newell, Anthony Nyong, David Ockwell, Marina Olshanskaya, Victor A. Orindi, James Painter, Peter D. Pederson, Serguey Pegov, Renat Perelet, Alberto Carillo Pineda, Vicky Pope, Golam Rabbani, Atiq Rahman, Mariam Rashid, Bimal R. Regmi, Hannah Reid, J. Timmons Roberts, Greet Ruysschaert, Boshra Salem, Jürgen Schmid, Dana Schüler, Rory Sullivan, Erika Trigoso Rubio, Md. Rabi Uzzaman, Giulio Volpi, Tao Wang, James Watson, Harald Winkler, Mikhail Yulkin and Yanchun Zhang.

Several organizations generously shared their data and other research materials: Agence Française de Développement; Amnesty International; Carbon Dioxide Information and Analysis Center; Caribbean Community

Secretariat; Center for International Comparisons of Production, Income and Prices at the University of Pennsylvania; Development Initiatives; Department for International Development; Environmental Change Institute at Oxford University; European Commission; Food and Agriculture Organization; Global Environment Facility; Global IDP Project; IGAD Climate Prediction and Applications Centre; Institute of Development Studies; International Centre for Prison Studies; Internally Displaced Monitoring Centre; International Research Institute for Climate and Society; International Energy Agency; International Institute for Environment and Development; International Institute for Strategic Studies; International Labour Organization; International Monetary Fund; International Organization for Migration; International Telecommunication Union; Inter-Parliamentary Union; Joint United Nations Programme on HIV/AIDS; Luxembourg Income Study; Macro International; Organisation for Economic Co-operation and Development; Overseas Development Institute; Oxfam; Pew Center for Climate Change; Practical Action Consulting; Stockholm International Peace Research Institute; Stockholm International Water Institute; Tata Energy Research Institute; Met Office; United Nations Children's Fund; United Nations Conference on Trade and Development; United Nations Department of Economic and Social Affairs, Statistics Division and Population Division; United Nations Development Fund for Women; United Nations Educational, Scientific and Cultural Organization, Institute for Statistics; United Nations High Commissioner for Refugees; United Nations Office on Drugs and Crime, Treaty Section; United Nations Office of Legal Affairs; University of East Anglia; WaterAid; World Bank; World Health Organization; World Meteorological Organization; World Trade Organization; World Intellectual Property Organization and the World Wildlife Fund.

Advisory Panel

The Report benefited greatly from intellectual advice and guidance provided by an external advisory panel of experts. The panel comprised Monique Barbut, Alicia Bárcena, Fatih Birol, Yvo de Boer, John R. Coomber, Mohammed T. El-Ashry, Paul Epstein, Peter T. Gilruth, José Goldemberg, HRH Crown Prince Haakon, Saleem Huq, Inge Kaul, Kivutha Kibwana, Akio Morishima, Rajendra Pachauri, Jiahua Pan, Achim Steiner, HRH Princess Basma Bint Talal, Colleen Vogel, Morris A. Ward, Robert Watson, Ngaire Woods and Stephen E. Zebiak. An advisory panel on statistics made an invaluable contribution, in particular Tom Griffin, the Report's Senior Statistical Advisor. The panel members are: Carla Abou-Zahr, Tony Atkinson, Haishan Fu, Gareth Jones, Ian D. Macredie, Anna N. Majelantle, John Male-Mukasa, Marion McEwin, Francesca Perucci, Tim Smeeding, Eric Swanson, Pervez Tahir and Michael Ward. The team is grateful to Partha Deb, Shea Rutstein and Michael Ward who reviewed and commented on an HDRO analysis of risk and vulnerability and lent their statistical expertise.

Consultations

Members of the Human Development Report team benefited individually and collectively from a wide-ranging process of consultation. Participants in a Human Development Network discussion provided some wide-ranging insights and observations on the linkages between climate change and human development. The Report team wishes also to thank Neil Adger, Keith Allott, Kristin Averyt, Armando Barrientos, Haresh Bhojwani, Paul Bledsoe, Thomas A. Boden, Keith Briffa, Nick Brooks, Katrina Brown, Miguel Ceara-Hatton, Fernando Calderón, Jacques Charmes, Lars Christiansen, Kirsty Clough, Stefan Dercon, Jaime de Melo, Stephen Devereux, Niky Fabiancic, Kimberley Fisher, Lawrence Flint, Claudio Forner, Jennifer Frankel-Reed, Ralph Friedlaender, Oscar Garcia, Stephen Gitonga, Heather Grady, Barbara Harris-White, Molly E. Hellmuth, John Hoddinott, Aminul Islam, Tarik-ul-Islam, Kareen Jabre, Fortunat Joos, Mamunul Khan, Karoly Kovacs, Diana Liverman, Lars Gunnar Marklund, Charles McKenzie, Gerald A. Meehl, Pierre Montagnier,

Jean-Robert Moret, Koos Neefjes, Iiris Niemi, Miroslav Ondras, Jonathan T. Overpeck, Vicky Pope, Will Prince, Kate Raworth, Andrew Revkin, Mary Robinson, Sherman Robinson, Rachel Slater, Leonardo Souza, Valentina Stoevska, Eric Swanson, Richard Tanner, Haiyan Teng, Jean Philippe Thomas, Steve Price Thomas, Sandy Tolan, Emma Tompkins, Emma Torres, Kevin E. Trenberth, Jessica Troni, Adriana Velasco, Marc Van Wynsberghe, Tessa Wardlaw and Richard Washington.

UNDP Readers

A Readers Group, made up of colleagues in UNDP, provided many useful comments, suggestions and inputs during the writing of the Report. Special mention must be made of the contribution and advice of Pedro Conceição, Charles Ian McNeil and Andrew Maskrey. All of them were generous with their time and made substantive contributions to the Report. Other inputs were received from: Randa Aboul-Hosn, Amat Al-Alim Alsoswa, Barbara Barungi, Winifred Byanyima, Suely Carvalho, Tim Clairs, Niamh Collier-Smith, Rosine Coulibaly, Maxx Dilley, Philip Dobie, Bjørn Førde, Tegegnework Gettu, Yannick Glemarec, Luis Gomez-Echeverri, Rebeca Grynspan, Raquel Herrera, Gilbert Fossoun Houngbo, Peter Hunnam, Ragnhild Imerslund, Andrey Ivanov, Bruce Jenks, Michael Keating, Douglas Keh, Olav Kjorven, Pradeep Kurukulasuriya, Oksana Leshchenko, Bo Lim, Xianfu Lu, Nora Lustig, Metsi Makhetha, Cécile Molinier, David Morrison, Tanni Mukhopadhyay, B. Murali, Simon Nhongo, Macleod Nyirongo, Hafiz Pasha, Stefano Pettinato, Selva Ramachandran, Marta Ruedas, Mounir Tabet, Jennifer Topping, Kori Udovicki, Louisa Vinton, Cassandra Waldon and Agostinho Zacarias.

Editing, Production and Translation

The Report benefited from the advice and contribution of an editorial team at Green Ink. Anne Moorhead provided advice on structure and presentation of the argument. Technical and production editing was carried out by Sue Hainsworth and Rebecca Mitchell. Cover and dividers were designed by Talking Box, with conceptual inputs by Martín Sánchez and Ruben Salinas, on the basis of a template designed by Grundy & Northedge in 2005. Information design was done by Phoenix Design Aid and Zago; one map (map 1.1) was designed by Mapping Worlds. Phoenix Design Aid, under the coordination of Lars Jørgensen, also did the Report's layout.

The production, translation, distribution and promotion of the Report benefited from the help and support of the UNDP Office of Communications, and particularly of Maureen Lynch and Boaz Paldi. Translations were reviewed by Iyad Abumoghli, Bill Bikales, Jean Fabre, Albéric Kacou, Madi Musa, Uladzimir Shcherbau and Oscar Yujnovsky.

The Report also benefited from the dedicated work of Jong Hyun Jeon, Isabelle Khayat, Caitlin Lu, Emily Morse and Lucio Severo. Swetlana Goobenkova and Emma Reed made valuable contributions to the statistical team. Margaret Chi and Juan Arbelaez of the UN Office of Project Services provided critical administrative support and management services.

Kevin Watkins
Director
Human Development Report 2007/2008

Contents

Boxes

Tables

Figures

Maps

Special contributions

Human development indicators

Fighting climate change: human solidarity in a divided world

"Human progress is neither automatic nor inevitable. We are faced now with the fact that tomorrow is today. We are confronted with the fierce urgency of now. In this unfolding conundrum of life and history there is such a thing as being too late...We may cry out desperately for time to pause in her passage, but time is deaf to every plea and rushes on. Over the bleached bones and jumbled residues of numerous civilizations are written the pathetic words: Too late."

Martin Luther King Jr. *'Where do we go from here: chaos or community'*

Delivered in a sermon on social justice four decades ago, Martin Luther King's words retain a powerful resonance. At the start of the 21st Century, we too are confronted with the "fierce urgency" of a crisis that links today and tomorrow. That crisis is climate change. It is still a preventable crisis—but only just. The world has less than a decade to change course. No issue merits more urgent attention—or more immediate action.

Climate change is the defining human development issue of our generation. All development is ultimately about expanding human potential and enlarging human freedom. It is about people developing the capabilities that empower them to make choices and to lead lives that they value. Climate change threatens to erode human freedoms and limit choice. It calls into question the Enlightenment principle that human progress will make the future look better than the past.

The early warning signs are already visible. Today, we are witnessing at first hand what could be the onset of major human development reversal in our lifetime. Across developing countries, millions of the world's poorest people are already being forced to cope with the impacts of climate change. These impacts do not register as apocalyptic events in the full glare of world media attention. They go unnoticed in financial markets and in the measurement of world gross domestic product (GDP). But increased exposure to drought, to more intense storms, to floods and environmental stress is holding back the efforts of the world's poor to build a better life for themselves and their children.

Climate change will undermine international efforts to combat poverty. Seven years ago, political leaders around the world gathered to set targets for accelerated progress in human development. The Millennium Development Goals (MDGs) defined a new ambition for 2015. Much has been achieved, though many countries remain off track. Climate change is hampering efforts to deliver the MDG promise. Looking to the future, the danger is that it will stall and then reverse progress built-up over generations not just in cutting extreme poverty, but in health, nutrition, education and other areas.

United Nations Development Programme, *Human Development Report 2007/2008*

Climate change provides a potent reminder of the one thing that we share in common. It is called planet Earth. All nations and all people share the same atmosphere

How the world deals with climate change today will have a direct bearing on the human development prospects of a large section of humanity. Failure will consign the poorest 40 percent of the world's population—some 2.6 billion people—to a future of diminished opportunity. It will exacerbate deep inequalities within countries. And it will undermine efforts to build a more inclusive pattern of globalization, reinforcing the vast disparities between the 'haves' and the 'have nots'.

In today's world, it is the poor who are bearing the brunt of climate change. Tomorrow, it will be humanity as a whole that faces the risks that come with global warming. The rapid build-up of greenhouse gases in the Earth's atmosphere is fundamentally changing the climate forecast for future generations. We are edging towards 'tipping points'. These are unpredictable and non-linear events that could open the door to ecological catastrophes—accelerated collapse of the Earth's great ice sheets being a case in point—that will transform patterns of human settlement and undermine the viability of national economies. Our generation may not live to see the consequences. But our children and their grandchildren will have no alternative but to live with them. Aversion to poverty and inequality today, and to catastrophic risk in the future provides a strong rationale for urgent action.

Some commentators continue to cite uncertainty over future outcomes as grounds for a limited response to climate change. That starting point is flawed. There are indeed many unknowns: climate science deals in probability and risk, not in certainties. However, if we value the well-being of our children and grandchildren, even small risks of catastrophic events merit an insurance-based precautionary approach. And uncertainty cuts both ways: the risks could be greater than we currently understand.

Climate change demands urgent action now to address a threat to two constituencies with a little or no political voice: the world's poor and future generations. It raises profoundly important questions about social justice, equity and human rights across countries and generations. In the *Human Development Report 2007/2008* we address these questions. Our starting point is that the battle against climate change can—and must—be won. The world lacks neither the financial resources nor the technological capabilities to act. If we fail to prevent climate change it will be because we were unable to foster the political will to cooperate.

Such an outcome would represent not just a failure of political imagination and leadership, but a moral failure on a scale unparalleled in history. During the 20th Century failures of political leadership led to two world wars. Millions of people paid a high price for what were avoidable catastrophes. Dangerous climate change is the avoidable catastrophe of the 21st Century and beyond. Future generations will pass a harsh judgement on a generation that looked at the evidence on climate change, understood the consequences and then continued on a path that consigned millions of the world's most vulnerable people to poverty and exposed future generations to the risk of ecological disaster.

Ecological interdependence

Climate change is different from other problems facing humanity—and it challenges us to think differently at many levels. Above all, it challenges us to think about what it means to live as part of an ecologically interdependent human community.

Ecological interdependence is not an abstract concept. We live today in a world that is divided at many levels. People are separated by vast gulfs in wealth and opportunity. In many regions, rival nationalisms are a source of conflict. All too often, religious, cultural and ethnic identity are treated as a source of division and difference from others. In the face of all these differences, climate change provides a potent reminder of the one thing that we share in common. It is called planet Earth. All nations and all people share the same atmosphere. And we only have one.

Global warming is evidence that we are overloading the carrying capacity of the Earth's atmosphere. Stocks of greenhouse gases that trap heat in the atmosphere are accumulating at an unprecedented rate. Current concentrations have reached 380

parts per million (ppm) of carbon dioxide equivalent (CO_2e) exceeding the natural range of the last 650,000 years. In the course of the 21st Century, average global temperatures could increase by more than 5°C.

To put that figure in context, it is equivalent to the change in temperature since the last ice age—an era in which much of Europe and North America was under more than one kilometre of ice. The threshold for dangerous climate change is an increase of around 2°C. This threshold broadly defines the point at which rapid reversals in human development and a drift towards irreversible ecological damage would become very difficult to avoid.

Behind the numbers and the measurement is a simple overwhelming fact. We are recklessly mismanaging our ecological interdependence. In effect, our generation is running up an unsustainable ecological debt that future generations will inherit. We are drawing down the stock of environmental capital of our children. Dangerous climate change will represent the adjustment to an unsustainable level of greenhouse gas emissions.

Future generations are not the only constituency that will have to cope with a problem they did not create. The world's poor will suffer the earliest and most damaging impacts. Rich nations and their citizens account for the overwhelming bulk of the greenhouse gases locked in the Earth's atmosphere. But, poor countries and their citizens will pay the highest price for climate change.

The inverse relationship between responsibility for climate change and vulnerability to its impacts is sometimes forgotten. Public debate in rich nations increasingly highlights the threat posed by rising greenhouse gas emissions from developing countries. That threat is real. But it should not obscure the underlying problem. Mahatma Gandhi once reflected on how many planets might be needed if India were to follow Britain's pattern of industrialization. We are unable to answer that question. However, we estimate in this Report that if all of the world's people generated greenhouse gases at the same rate as some developed countries, we would need nine planets.

While the world's poor walk the Earth with a light carbon footprint they are bearing the brunt of unsustainable management of our ecological interdependence. In rich countries, coping with climate change to date has largely been a matter of adjusting thermostats, dealing with longer, hotter summers, and observing seasonal shifts. Cities like London and Los Angeles may face flooding risks as sea levels rise, but their inhabitants are protected by elaborate flood defence systems. By contrast, when global warming changes weather patterns in the Horn of Africa, it means that crops fail and people go hungry, or that women and young girls spend more hours collecting water. And, whatever the future risks facing cities in the rich world, today the real climate change vulnerabilities linked to storms and floods are to be found in rural communities in the great river deltas of the Ganges, the Mekong and the Nile, and in sprawling urban slums across the developing world.

The emerging risks and vulnerabilities associated with climate change are the outcomes of physical processes. But they are also a consequence of human actions and choices. This is another aspect of ecological interdependence that is sometimes forgotten. When people in an American city turn on the air-conditioning or people in Europe drive their cars, their actions have consequences. Those consequences link them to rural communities in Bangladesh, farmers in Ethiopia and slum dwellers in Haiti. With these human connections come moral responsibilities, including a responsibility to reflect upon—and change—energy policies that inflict harm on other people or future generations.

The case for action

If the world acts now it will be possible—just possible—to keep 21st Century global temperature increases within a 2°C threshold above preindustrial levels. Achieving this future will require a high level of leadership and unparalleled international cooperation. Yet climate change is a threat that comes with an opportunity. Above all, it provides an opportunity for the world to

We are recklessly mismanaging our ecological interdependence. Our generation is running up an unsustainable ecological debt that future generations will inherit

The real choice facing political leaders and people today is between universal human values, on the one side, and participating in the widespread and systematic violation of human rights on the other

come together in forging a collective response to a crisis that threatens to halt progress.

The values that inspired the drafters of the Universal Declaration of Human Rights provide a powerful point of reference. That document was a response to the political failure that gave rise to extreme nationalism, fascism and world war. It established a set of entitlements and rights—civil, political, cultural, social and economic—for "all members of the human family". The values that inspired the Universal Declaration were seen as a code of conduct for human affairs that would prevent the "disregard and contempt for human rights that have resulted in barbarous acts which have outraged the conscience of mankind".

The drafters of the Universal Declaration of Human Rights were looking back at a human tragedy, the second world war, that had already happened. Climate change is different. It is a human tragedy in the making. Allowing that tragedy to evolve would be a political failure that merits the description of an "outrage to the conscience of mankind". It would represent a systematic violation of the human rights of the world's poor and future generations and a step back from universal values. Conversely, preventing dangerous climate change would hold out the hope for the development of multilateral solutions to the wider problems facing the international community. Climate change confronts us with enormously complex questions that span science, economics and international relations. These questions have to be addressed through practical strategies. Yet it is important not to lose sight of the wider issues that are at stake. The real choice facing political leaders and people today is between universal human values, on the one side, and participating in the widespread and systematic violation of human rights on the other.

The starting point for avoiding dangerous climate change is recognition of three distinctive features of the problem. The first feature is the combined force of inertia and cumulative outcomes of climate change. Once emitted, carbon dioxide (CO_2) and other greenhouse gases stay in the atmosphere for a long time. There are no rapid rewind buttons for running down stocks. People living at the start of the 22nd Century will live with the consequences of our emissions, just as we are living with the consequences of emissions since the industrial revolution. Time-lags are an important consequence of climate change inertia. Even stringent mitigation measures will not materially affect average temperatures changes until the mid-2030s—and temperatures will not peak until 2050. In other words, for the first half of the 21st Century the world in general, and the world's poor in particular, will have to live with climate change to which we are already committed.

The cumulative nature of the climate change has wide-ranging implications. Perhaps the most important is that carbon cycles do not follow political cycles. The current generation of political leaders cannot solve the climate change problem alone because a sustainable emissions pathway has to be followed over decades, not years. However, it has the power either to prise open the window of opportunity for future generations, or to close that window.

Urgency is the second feature of the climate change challenge—and a corollary of inertia. In many other areas of international relations, inaction or delayed agreements have limited costs. International trade is an example. This is an area in which negotiations can break down and resume without inflicting long-term damage on the underlying system—as witnessed by the unhappy history of the Doha Round. With climate change, every year of delay in reaching an agreement to cut emissions adds to greenhouse gas stocks, locking the future into a higher temperature. In the seven years since the Doha Round started, to continue the analogy, stocks of greenhouse gases have increased by around 12 ppm of CO_2e—and those stocks will still be there when the trade rounds of the 22nd Century get underway.

There are no obvious historical analogies for the urgency of the climate change problem. During the Cold War, large stockpiles of nuclear missiles pointed at cities posed a grave threat to human security. However, 'doing nothing' was a strategy for containment of the risks. Shared recognition of the reality of mutually assured

destruction offered a perversely predictable stability. With climate change, by contrast, doing nothing offers a guaranteed route to a further build-up greenhouse gases, and to mutually assured destruction of human development potential.

The third important dimension of the climate change challenge is its global scale. The Earth's atmosphere does not differentiate greenhouse gases by country of origin. One tonne of greenhouse gases from China carries the same weight as one tonne of greenhouse gases from the United States—and one country's emissions are another country's climate change problem. It follows that no one country can win the battle against climate change acting alone. Collective action is not an option but an imperative. When Benjamin Franklin signed the American Declaration of Independence in 1776, he is said to have commented: "We must all hang together, or most assuredly, we shall all hang separately." In our unequal world, some people—notably poor people—might hang sooner than others in the event of a failure to develop collective solutions. But ultimately, this is a preventable crisis that threatens all people and all countries. We too have the choice between hanging together and forging collective solutions to a shared problem, or hanging separately.

Seizing the moment—2012 and beyond

Confronted with a problem as daunting as climate change, resigned pessimism might seem a justified response. However, resigned pessimism is a luxury that the world's poor and future generations cannot afford—and there is an alternative.

There is cause for optimism. Five years ago, the world was still engaged in debating whether or not climate change was taking place, and whether or not it was human-induced. Climate change scepticism was a flourishing industry. Today, the debate is over and climate scepticism is an increasingly fringe activity. The fourth assessment review of the International Panel on Climate Change has established an overwhelming scientific consensus that climate change is both real and man-made. Almost all governments are part of that consensus. Following the publication of the Stern Review on *The Economics of Climate Change*, most governments also accept that solutions to climate change are affordable—more affordable than the costs of inaction.

Political momentum is also gathering pace. Many governments are setting bold targets for cutting greenhouse gas emissions. Climate change mitigation has now registered firmly on the agenda of the Group of Eight (G8) industrialized nations. And dialogue between developed and developing countries is strengthening.

All of this is positive news. Practical outcomes are less impressive. While governments may recognize the realities of global warming, political action continues to fall far short of the minimum needed to resolve the climate change problem. The gap between scientific evidence and political response remains large. In the developed world, some countries have yet to establish ambitious targets for cutting greenhouse gas emissions. Others have set ambitious targets without putting in place the energy policy reforms needed to achieve them. The deeper problem is that the world lacks a clear, credible and long-term multilateral framework that charts a course for avoiding dangerous climate change—a course that spans the divide between political cycles and carbon cycles.

With the expiry of the current commitment period of the Kyoto Protocol in 2012, the international community has an opportunity to put that framework in place. Seizing that opportunity will require bold leadership. Missing it will push the world further on the route to dangerous climate change.

Developed countries have to take the lead. They carry the burden of historic responsibility for the climate change problem. And they have the financial resources and technological capabilities to initiate deep and early cuts in emissions. Putting a price on carbon through taxation or cap-and-trade systems is the starting point. But market pricing alone will not be enough. The development of regulatory systems and public–private partnerships for a low-carbon transition are also priorities.

No one country can win the battle against climate change acting alone. Collective action is not an option but an imperative

The world's poor and future generations cannot afford the complacency and prevarication that continues to characterize international negotiations on climate change

The principle of "common but differentiated responsibility"—one of the foundations of the Kyoto framework—does not mean that developing countries should do nothing. The credibility of any multilateral agreement will hinge on the participation of major emitters in the developing world. However, basic principles of equity and the human development imperative of expanding access to energy demand that developing countries have the flexibility to make the transition to a low-carbon growth path at a rate consistent with their capabilities.

International cooperation has a critical role to play at many levels. The global mitigation effort would be dramatically enhanced if a post-2012 Kyoto framework incorporated mechanisms for finance and technology transfers. These mechanisms could help remove obstacles to the rapid disbursement of the low-carbon technologies needed to avoid dangerous climate change. Cooperation to support the conservation and sustainable management of rainforests would also strengthen the mitigation effort.

Adaptation priorities must also be addressed. For too long, climate change adaptation has been treated as a peripheral concern, rather than as a core part of the international poverty reduction agenda. Mitigation is an imperative because it will define prospects for avoiding dangerous climate change in the future. But the world's poor cannot be left to sink or swim with their own resources while rich countries protect their citizens behind climate-defence fortifications. Social justice and respect of human rights demand stronger international commitment on adaptation.

Our legacy

The post-2012 Kyoto framework will powerfully influence prospects for avoiding climate change—and for coping with the climate change that is now unavoidable. Negotiations on that framework will be shaped by governments with very different levels of negotiating leverage. Powerful vested interests in the corporate sector will also make their voices heard. As governments embark on the negotiations for a post-2012 Kyoto Protocol, it is important that they reflect on two constituencies with a limited voice but a powerful claim to social justice and respect for human rights: the world's poor and future generations.

People engaged in a daily struggle to improve their lives in the face of grinding poverty and hunger ought to have first call on human solidarity. They certainly deserve something more than political leaders who gather at international summits, set high-sounding development targets and then undermine achievement of the very same targets by failing to act on climate change. And our children and their children's grandchildren have the right to hold us to a high standard of accountability when their future—and maybe their survival—is hanging in the balance. They too deserve something more than a generation of political leaders who look at the greatest challenge humankind has ever faced and then sit on their hands. Put bluntly, the world's poor and future generations cannot afford the complacency and prevarication that continues to characterize international negotiations on climate change. Nor can they afford the large gap between what leaders in the developed world say about climate change threats and what they do in their energy policies.

Twenty years ago Chico Mendes, the Brazilian environmentalist, died attempting to defend the Amazon rainforest against destruction. Before his death, he spoke of the ties that bound his local struggle to a global movement for social justice: "At first I thought I was fighting to save rubber trees, then I thought I was fighting to save the Amazon rainforest. Now I realise I am fighting for humanity."

The battle against dangerous climate change is part of the fight for humanity. Winning that battle will require far-reaching changes at many levels—in consumption, in how we produce and price energy, and in international cooperation. Above all, though, it will require far-reaching changes in how we think about our ecological interdependence, about social justice for the world's poor, and about the human rights and entitlements of future generations.

The 21st Century climate challenge

Global warming is already happening. World temperatures have increased by around 0.7°C

since the advent of the industrial era—and the rate of increase is quickening. There is overwhelming scientific evidence linking the rise in temperature to increases in the concentration of greenhouse gases in the Earth's atmosphere.

There is no hard-and-fast line separating 'dangerous' from 'safe' climate change. Many of the world's poorest people and most fragile ecological systems are already being forced to adapt to dangerous climate change. However, beyond a threshold of 2°C the risk of large-scale human development setbacks and irreversible ecological catastrophes will increase sharply.

Business-as-usual trajectories will take the world well beyond that threshold. To have a 50:50 chance of limiting temperature increase to 2°C above preindustrial levels will require stabilization of greenhouse gases at concentrations of around 450ppm CO_2e. Stabilization at 550ppm CO_2e would raise the probability of breaching the threshold to 80 percent. In their personal lives, few people would knowingly undertake activities with a serious injury risk of this order of magnitude. Yet as a global community, we are taking far greater risks with planet Earth. Scenarios for the 21st Century point to potential stabilization points in excess of 750ppm CO_2e, with possible temperature changes in excess of 5°C.

Temperature scenarios do not capture the potential human development impacts. Average changes in temperature on the scale projected in business-as-usual scenarions will trigger large-scale reversals in human development, undermining livelihoods and causing mass displacement. By the end of the 21st Century, the spectre of catastrophic ecological impacts could have moved from the bounds of the possible to the probable. Recent evidence on the accelerated collapse of ice sheets in the Antarctic and Greenland, acidification of the oceans, the retreat of rainforest systems and melting of Arctic permafrost all have the potential—separately or in interaction—to lead to 'tipping points'.

Countries vary widely in their contribution to the emissions that are driving up atmospheric stocks of greenhouse gases. With 15 percent of world population, rich countries account for almost half of emissions of CO_2. High growth in China and India is leading to a gradual convergence in 'aggregate' emissions. However, per capita carbon footprint convergence is more limited. The carbon footprint of the United States is five times that of China and over 15 times that of India. In Ethiopia, the average per capita carbon footprint is 0.1 tonnes of CO_2 compared with 20 tonnes in Canada.

What does the world have to do to get on an emissions trajectory that avoids dangerous climate change? We address that question by drawing upon climate modeling simulations. These simulations define a carbon budget for the 21st Century.

If everything else were equal, the global carbon budget for energy-related emissions would amount to around 14.5 Gt CO_2 annually. Current emissions are running at twice this level. The bad news is that emissions are on a rising trend. The upshot: the carbon budget for the entire 21st Century could expire as early as 2032. In effect, we are running up unsustainable ecological debts that will lock future generations into dangerous climate change.

Carbon budget analysis casts a new light on concerns over the share of developing countries in global greenhouse gas emissions. While that share is set to rise, it should not divert attention from the underlying responsibilities of rich nations. If every person in the developing world had the same carbon footprint as the average person in Germany or the United Kingdom, current global emissions would be four times the limit defined by our sustainable emissions pathway, rising to nine times if the developing country per capita footprint were raised to Canadian or United States levels.

Changing this picture will require deep adjustments. If the world were a single country it would have to cut emissions of greenhouse gases by half to 2050 relative to 1990 levels, with sustained reductions to the end of the 21st Century. However, the world is not a single country. Using plausible assumptions, we estimate that avoiding dangerous climate change will require rich nations to cut emissions by at least 80 percent, with cuts of 30 percent by 2020. Emissions from developing countries would peak around 2020, with cuts of 20 percent by 2050.

By the end of the 21st Century, the spectre of catastrophic ecological impacts could have moved from the bounds of the possible to the probable

Current investment patterns are putting in place a carbon intensive energy infrastructure, with coal playing a dominant role

Our stabilization target is stringent but affordable. Between now and 2030, the average annual cost would amount to 1.6 percent of GDP. This is not an insignificant investment. But it represents less than two-thirds of global military spending. The costs of inaction could be much higher. According to the Stern Review, they could reach 5–20 percent of world GDP, depending upon how costs are measured.

Looking back at emission trends highlights the scale of the challenge ahead. Energy related CO_2 emissions have increased sharply since 1990, the reference years for the reductions agreed under the Kyoto Protocol. Not all developed countries ratified the Protocol's targets, which would have reduced their average emissions by around 5 percent. Most of those that did are off track for achieving their commitments. And few of those that are on track can claim to have reduced emissions as a result of a policy commitment to climate change mitigation. The Kyoto Protocol did not place any quantitative restrictions on emissions from developing countries. If the next 15 years of emissions follows the linear trend of the past 15, dangerous climate change will be unavoidable.

Projections for energy use point precisely in this direction, or worse. Current investment patterns are putting in place a carbon intensive energy infrastructure, with coal playing a dominant role. On the basis of current trends and present policies, energy-related CO_2 emissions could rise by more than 50 percent over 2005 levels by 2030. The US$20 trillion projected to be spent between 2004 and 2030 to meet energy demand could lock the world on to an unsustainable trajectory. Alternatively, new investments could help to decarbonize economic growth.

Climate shocks: risk and vulnerability in an unequal world

Climate shocks already figure prominently in the lives of the poor. Events such as droughts, floods and storms are often terrible experiences for those affected: they threaten lives and leave people feeling insecure. But climate shocks also erode long-term opportunities for human development, undermining productivity and eroding human capabilities. No single climate shock can be attributed to climate change. However, climate change is ratcheting up the risks and vulnerabilities facing the poor. It is placing further stress on already over-stretched coping mechanisms and trapping people in downward spirals of deprivation.

Vulnerability to climate shocks is unequally distributed. Hurricane Katrina provided a potent reminder of human frailty in the face of climate change even in the richest countries—especially when the impacts interact with institutionalized inequality. Across the developed world, public concern over exposure to extreme climate risks is mounting. With every flood, storm and heat wave, that concern is increasing. Yet climate disasters are heavily concentrated in poor countries. Some 262 million people were affected by climate disasters annually from 2000 to 2004, over 98 percent of them in the developing world. In the Organisation for Economic Co-operation and Development (OECD) countries one in 1,500 people was affected by climate disaster. The comparable figure for developing countries is one in 19—a risk differential of 79.

High levels of poverty and low levels of human development limit the capacity of poor households to manage climate risks. With limited access to formal insurance, low incomes and meagre assets, poor households have to deal with climate-related shocks under highly constrained conditions.

Strategies for coping with climate risks can reinforce deprivation. Producers in drought prone areas often forego production of crops that could raise income in order to minimize risk, preferring to produce crops with lower economic returns but resistant to drought. When climate disasters strike, the poor are often forced to sell productive assets, with attendant implications for recovery, in order to protect consumption. And when that is not enough households cope in other ways: for example, by cutting meals, reducing spending on health and taking children out of school. These are desperation measures that can create life-long cycles of disadvantage, locking vulnerable households into low human development traps.

Research carried out for this report underlines just how potent these traps can be. Using microlevel household data we examined some of the long-term impacts of climate-shocks in the lives of the poor. In Ethiopia and Kenya, two of the world's most drought-prone countries, children aged five or less are respectively 36 and 50 percent more likely to be malnourished if they were born during a drought. For Ethiopia, that translates into some 2 million additional malnourished children in 2005. In Niger, children aged two or less born in a drought year were 72 percent more likely to be stunted. And Indian women born during a flood in the 1970s were 19 percent less likely to have attended primary school.

The long-run damage to human development generated through climate shocks is insufficiently appreciated. Media reporting of climate-related disasters often plays an important role in informing opinion—and in capturing the human suffering that comes with climate shocks. However, it also gives rise to a perception that these are 'here-today-gone-tomorrow' experiences, diverting attention from the long-run human consequences of droughts and floods.

Climate change will not announce itself as an apocalyptic event in the lives of the poor. Direct attribution of any specific event to climate change will remain impossible. However, climate change will steadily increase the exposure of poor and vulnerable households to climate-shocks and place increased pressure on coping strategies, which, over time, could steadily erode human capabilities.

We identify five key transmission mechanisms through which climate change could stall and then reverse human development:

- *Agricultural production and food security.* Climate change will affect rainfall, temperature and water availability for agriculture in vulnerable areas. For example, drought-affected areas in sub-Saharan Africa could expand by 60–90 million hectares, with dry land zones suffering losses of US$26 billion by 2060 (2003 prices), a figure in excess of bilateral aid to the region in 2005. Other developing regions—including Latin America and South Asia—will also experience losses in agricultural production, undermining efforts to cut rural poverty. The additional number affected by malnutrition could rise to 600 million by 2080.
- *Water stress and water insecurity.* Changed run-off patterns and glacial melt will add to ecological stress, compromising flows of water for irrigation and human settlements in the process. An additional 1.8 billion people could be living in a water scarce environment by 2080. Central Asia, Northern China and the northern part of South Asia face immense vulnerabilities associated with the retreat of glaciers—at a rate of 10–15 metres a year in the Himalayas. Seven of Asia's great river systems will experience an increase in flows over the short term, followed by a decline as glaciers melt. The Andean region also faces imminent water security threats with the collapse of tropical glaciers. Several countries in already highly water-stressed regions such as the Middle East could experience deep losses in water availability.
- *Rising sea levels and exposure to climate disasters.* Sea levels could rise rapidly with accelerated ice sheet disintegration. Global temperature increases of 3–4°C could result in 330 million people being permanently or temporarily displaced through flooding. Over 70 million people in Bangladesh, 6 million in Lower Egypt and 22 million in Viet Nam could be affected. Small island states in the Caribbean and Pacific could suffer catastrophic damage. Warming seas will also fuel more intense tropical storms. With over 344 million people currently exposed to tropical cyclones, more intensive storms could have devastating consequences for a large group of countries. The 1 billion people currently living in urban slums on fragile hillsides or flood-prone river banks face acute vulnerabilities.
- *Ecosystems and biodiversity.* Climate change is already transforming ecological systems. Around one-half of the world's coral reef systems have suffered 'bleaching' as a result of warming seas. Increasing acidity in the oceans is another long-term threat to marine ecosystems. Ice-based ecologies have also suffered devastating climate change

Global temperature increases of 3–4°C could result in 330 million people being permanently or temporarily displaced through flooding

Avoiding the unprecedented threats posed by dangerous climate change will require an unparalleled collective exercise in international cooperation

impacts, especially in the Arctic region. While some animal and plant species will adapt, for many species the pace of climate change is too rapid: climate systems are moving more rapidly than they can follow. With 3°C of warming, 20–30 percent of land species could face extinction.

- *Human health.* Rich countries are already preparing public health systems to deal with future climate shocks, such as the 2003 European heatwave and more extreme summer and winter conditions. However, the greatest health impacts will be felt in developing countries because of high levels of poverty and the limited capacity of public health systems to respond. Major killer diseases could expand their coverage. For example, an additional 220–400 million people could be exposed to malaria—a disease that already claims around 1 million lives annually. Dengue fever is already in evidence at higher levels of elevation than has previously been the case, especially in Latin America and parts of East Asia. Climate change could further expand the reach of the disease.

None of these five separate drivers will operate in isolation. They will interact with wider social, economic and ecological processes that shape opportunities for human development. Inevitably, the precise mix of transmission mechanisms from climate change to human development will vary across and within countries. Large areas of uncertainty remain. What is certain is that dangerous climate change has the potential to deliver powerful systemic shocks to human development across a large group of countries. In contrast to economic shocks that affect growth or inflation, many of the human development impacts—lost opportunities for health and education, diminished productive potential, loss of vital ecological systems, for example—are likely to prove irreversible.

Avoiding dangerous climate change: strategies for mitigation

Avoiding the unprecedented threats posed by dangerous climate change will require an unparalleled collective exercise in international cooperation. Negotiations on emission limits for the post-2012 Kyoto Protocol commitment period can—and must—frame the global carbon budget. However, a sustainable global emissions pathway will only be meaningful if it is translated into practical national strategies—and national carbon budgets. Climate change mitigation is about transforming the way that we produce and use energy. And it is about living within the bounds of ecological sustainability.

Setting credible targets linked to global mitigation goals is the starting point for the transition to a sustainable emissions pathway. These targets can provide a basis for carbon budgeting exercises that provide a link from the present to the future through a series of rolling plans. However, credible targets have to be backed by clear policies. The record to date in this area is not encouraging. Most developed countries are falling short of the targets set under the Kyoto Protocol: Canada is an extreme case in point. In some cases, ambitious 'Kyoto-plus' targets have been adopted. The European Union and the United Kingdom have both embraced such targets. For different reasons, they are both likely to fall far short of the goals set unless they move rapidly to put climate mitigation at the centre of energy policy reform.

Two major OECD countries are not bound by Kyoto targets. Australia has opted for a wide-ranging voluntary initiative, which has produced mixed results. The United States does not have a federal target for reducing emissions. Instead, it has a 'carbon-intensity' reduction goal which measures efficiency. The problem is that efficiency gains have failed to prevent large aggregate increases in emissions. In the absence of federal targets, several United States' states have set their own mitigation goals. California's Global Warming Solutions Act of 2006 is a bold attempt to align greenhouse gas reduction targets with reformed energy policies.

Setting ambitious targets for mitigation is an important first step. Translating targets into policies is politically more challenging. The starting point: putting a price on carbon emissions. Changed incentive structures are a vital condition for an accelerated transition to low-carbon growth. In an optimal scenario, the

carbon price would be global. This is politically unrealistic in the short-run because the world lacks the required governance system. The more realistic option is for rich countries to develop carbon pricing structures. As these structures evolve, developing countries could be integrated over time as institutional conditions allow.

There are two ways of putting a price on carbon. The first is to directly tax CO_2 emissions. Importantly, carbon taxation does not imply an increase in the overall tax burden. The revenues can be used in a fiscally neutral way to support wider environmental tax reforms—for example, cutting taxes on labour and investment. Marginal taxation levels would require adjustment in the light of greenhouse gas emission trends. One approach, broadly consistent with our sustainable emissions pathway, would entail the introduction of taxation at a level of US$10–20/t CO_2 in 2010, rising in annual increments of US$5–10/t CO_2 towards a level of US$60–100/t CO_2. Such an approach would provide investors and markets with a clear and predictable framework for planning future investments. And it would generate strong incentives for a low-carbon transition.

The second route to carbon pricing is cap-and-trade. Under a cap-and-trade system, the government sets an overall emissions cap and issues tradable allowances that grant business the right to emit a set amount. Those who can reduce emissions more cheaply are able to sell allowances. One potential disadvantage of cap-and-trade is energy price instability. The potential advantage is environmental certainty: the cap itself is a quantitative ceiling applied to emissions. Given the urgency of achieving deep and early quantitative cuts in greenhouse gas emissions, well-designed cap-and-trade programmes have the potential to play a key role in mitigation.

The European Union's Emissions Trading Scheme (ETS), is the world's largest cap-and-trade programme. While much has been achieved, there are serious problems to be addressed. The caps on emissions have been set far too high, primarily because of the failure of European Union member states to resist the lobbying efforts of powerful vested interests. Some sectors—notably power—have secured windfall gains at public expense. And only a small fraction of ETS permits—less than 10 percent in the second phase—can be auctioned, depriving governments of revenue for tax reform and opening the door to political manipulation and generating inefficiencies. Restricting ETS quota allocations in line with the European Union's commitment to a 20–30 percent cut in emissions by 2020 would help to align carbon markets with mitigation goals.

Carbon markets are a necessary condition for the transition to a low-carbon economy. They are not a sufficient condition. Governments have a critical role to play in setting regulatory standards and in supporting low-carbon research, development and deployment.

There is no shortage of positive examples. Renewable energy provision is expanding in part because of the creation of incentives through regulation. In Germany, the 'feed-in' tariff has boosted the share of renewable suppliers in the national grid. The United States has successfully used tax incentives to encourage the development of a vibrant wind power industry. However, while the rapid growth of renewable energy has been encouraging, overall progress falls far short of what is possible—and of what is required for climate change mitigation. Most OECD countries have the potential to raise the share of renewable energy in power generation to at least 20 percent.

Enhanced energy efficiency has the potential to deliver a 'double dividend'. It can reduce CO_2 emissions *and* cut energy costs. If all electrical appliances operating in OECD countries in 2005 had met the best efficiency standards, it would have saved some 322 Mt CO_2 of emissions by 2010—equivalent to taking over 100 million cars off the road. Household electricity consumption would fall by one-quarter.

Personal transportation is another area where regulatory standards can unlock double-dividends. The automobile sector accounts for about 30 percent of greenhouse gas emissions in developed countries—and the share is rising. Regulatory standards matter because they can influence fleet efficiency, or the average number of miles travelled per gallon (and hence CO_2 emissions). In the United States,

Carbon markets are a necessary condition for the transition to a low-carbon economy. They are not a sufficient condition

The rapid development and deployment of low-carbon technologies is vital to climate change mitigation

fuel efficiency standards have slipped over time. They are now lower than in China. Raising standards by 20 miles per gallon would cut oil consumption by 3.5 million barrels a day and save 400 Mt CO_2 emissions a year—more than the total emissions from Thailand. Efforts to raise fuel efficiency standards are often countered by powerful vested interests. In Europe, for example, European Commission proposals to raise standards have been countered by a coalition of automobile manufacturers. Several member states have rejected the proposals, raising wider questions about the European Union's capacity to translate climate change goals into tangible policies.

International trade could play a much larger role in expanding markets for alternative fuels. Brazil is more efficient than either the European Union or the United States in producing ethanol. Moreover, sugar-based ethanol is more efficient at cutting carbon emissions. The problem is that imports of Brazilian ethanol are restricted by high import tariffs. Removing these tariffs would generate gains not just for Brazil, but for climate change mitigation.

The rapid development and deployment of low-carbon technologies is vital to climate change mitigation. Picking winners in technology is a hazardous affair. Governments have at best a mixed record. However, confronted with a national and global threat on the scale of climate change, governments cannot afford to stand back and wait for markets to deliver. Energy policy is an area in which the scale of upfront investments, time horizon, and uncertainty combine to guarantee that markets alone will fail to deliver technological change at the pace required by mitigation. In earlier periods, major technological breakthroughs have followed decisive government action: the Manhattan Project and the United States space programme are examples.

Carbon Capture and Storage (CSS) is a key breakthrough technology. Coal is the major source of power for electricity generation worldwide. Reserves are widely dispersed. Coupled with rising prices for oil and natural gas, this is one reason why coal figures prominently in the present and planned energy mix of major emitters such as the China, India and the United States. CCS is important because it holds out the promise of coal-fired power generation with near-zero emissions. With a more active programme of public–private investment, aligned with carbon pricing, CCS technologies could be developed and deployed more rapidly. Both the European Union and the United States have the capacity to put in place at least 30 demonstration plants by 2015.

Low levels of energy efficiency in developing countries are currently a threat to climate change mitigation efforts. Raising efficiency levels through international cooperation could transform that threat into an opportunity, generating large gains for human development in the process. We demonstrate this by examining the impact on CO_2 emissions of an accelerated technology transfer programme for the coal sector in China. For China alone, emissions in 2030 would be 1.8 Gt CO_2 below the level projected by the International Energy Agency. That figure is equivalent to around one-half of current European Union emissions. Similar efficiency gains are attainable in other areas.

Enhanced energy efficiency is a win–win scenario. Developing countries stand to gain from improved energy efficiency and lower environmental pollution. All countries stand to gain from CO_2 mitigation. Unfortunately, the world currently lacks a credible mechanism for unlocking this win–win scenario. We propose the development, under the auspices of the post-2012 Kyoto framework, of a Climate Change Mitigation Facility (CCMF) to fill this gap. The CCMF would mobilize US$25–50 billion annually to finance low-carbon energy investments in developing countries. Financing provisions would be linked to the circumstances of individual countries, with a menu of grants, concessional support and risk guarantees available. Support would be programme-based. It would cover the incremental costs of achieving defined emission reduction targets by scaling-up nationally-owned energy policies in areas such as renewable energy, clean coal and enhanced efficiency standards for transport and buildings.

Deforestation is another key area for international cooperation. Currently, the world is losing the carbon assets contained in rainforests at a fraction of the market value they would have even at low carbon prices. In Indonesia, every US$1 generated through deforestation to grow palm oil would translate into a US$50–100 loss if the reduced carbon capacity could be traded on the European Union's ETS. Beyond these market failures, the loss of rainforests represents the erosion of a resource that plays a vital role in the lives of the poor, in the provision of ecosystem services and in sustaining biodiversity.

There is scope for exploring the potential of carbon markets in the creation of incentives to avoid deforestation. More broadly, carbon finance could be mobilized to support the restoration of degraded grasslands, generating benefits for climate change mitigation, adaptation and environmental sustainability.

Adapting to the inevitable: national action and international cooperation

Without urgent mitigation action the world cannot avoid dangerous climate change. But even the most stringent mitigation will be insufficient to avoid major human development setbacks. The world is already committed to further warming because of the inertia built into climate systems and the delay between mitigation and outcome. For the first half of the 21st Century there is no alternative to adaptation to climate change.

Rich countries already recognize the imperative to adapt. Many are investing heavily in the development of climate defence infrastructures. National strategies are being drawn up to prepare for more extreme and less certain future weather patterns. The United Kingdom is spending US$1.2 billion annually on flood defences. In the Netherlands, people are investing in homes that can float on water. The Swiss alpine ski industry is investing in artificial snow-making machines.

Developing countries face far more severe adaptation challenges. Those challenges have to be met by governments operating under severe financing constraints, and by poor people themselves. In the Horn of Africa, 'adaptation' means that women and young girls walk further to collect water. In the Ganges Delta, people are erecting bamboo flood shelters on stilts. And in the Mekong Delta people are planting mangroves to protect themselves against storm surges, and women and children are being taught to swim.

Inequalities in capacity to adapt to climate change are becoming increasingly apparent. For one part of the world—the richer part—adaptation is a matter of erecting elaborate climate defence infrastructures, and of building homes that 'float on' water. In the other part adaptation means people themselves learning to 'float in' flood water. Unlike people living behind the flood defences of London and Los Angeles, young girls in the Horn of Africa and people in the Ganges Delta do not have a deep carbon footprint. As Desmond Tutu, the former Archbishop of Cape Town, has argued, we are drifting into a world of adaptation apartheid.

We are drifting into a world of adaptation apartheid

Planning for climate change adaptation confronts governments in developing countries with challenges at many levels. These challenges pose systemic threats. In Egypt, delta flooding could transform conditions for agricultural production. Changes to coastal currents in southern Africa could compromise the future of Namibia's fisheries sector. Hydroelectric power generation will be affected in many countries.

Responding to climate change will require the integration of adaptation into all aspects of policy development and planning for poverty reduction. However, planning and implementation capacity is limited:

- *Information*. Many of the world's poorest countries lack the capacity and the resources to assess climate risks. In sub-Saharan Africa, high levels of rural poverty and dependence on rainfed agriculture makes meteorological information an imperative for adaptation. However, the region has the world's lowest density of meteorological stations. In France, the meteorological budget amounts to US$388 million annually, compared with just US$2 million in Ethiopia. The 2005 G8 summit pledged action to strengthen Africa's meteorological monitoring capacity.

Support for the MDGs provides another powerful rationale for action: adaptation is a key requirement for achieving the 2015 targets and creating the conditions for sustained progress

Follow-up has fallen far short of the commitments made.

- *Infrastructure.* In climate change adaptation, as in other areas, prevention is better than cure. Every US$1 invested in pre-disaster risk management in developing countries can prevent losses of US$7. In Bangladesh, research among impoverished populations living on *char* islands shows that adaptation against flooding can strengthen livelihoods, even in extreme conditions. Many countries lack the financial resources required for infrastructural adaptation. Beyond disaster prevention, the development of community-based infrastructure for water harvesting can reduce vulnerability and empower people to cope with climate risks. Partnerships between communities and local governments in Indian states such as Andhra Pradesh and Gujarat provide examples of what can be achieved.
- *Insurance for social protection.* Climate change is generating incremental risks in the lives of the poor. Social protection programmes can help people cope with those risks while expanding opportunities for employment, nutrition and education. In Ethiopia the Productive Safety Net Programme is an attempt to strengthen the capacity of poor households to cope with droughts without having to sacrifice opportunities for health and education. In Latin America conditional cash transfers have been widely used to support a wide range of human development goals, including the protection of basic capabilities during a sudden crisis. In southern Africa cash transfers have been used during droughts to protect long-run productive capacity. While social protection figures only marginally in current climate change adaptation strategies, it has the potential to create large human development returns.

The case for international action on adaptation is rooted in past commitments, shared values, the global commitment to poverty reduction and the liability of rich nations for climate change problems. Under the terms of the United Nations Framework Convention on Climate Change (UNFCCC), northern governments are obliged to support adaptation capacity development. Support for the MDGs provides another powerful rationale for action: adaptation is a key requirement for achieving the 2015 targets and creating the conditions for sustained progress. Application of the legal principles of protection from harm and compensation for damage would constitute further grounds for action.

Expressed in diplomatic language, the international response on adaptation has fallen far short of what is required. Several dedicated multilateral financing mechanisms have been created, including the Least Developed Country Fund and the Special Climate Change Fund. Delivery through these mechanisms has been limited. Total financing to date has amounted to around US$26 million—a derisory response. For purposes of comparison, this is equivalent to one week's worth of spending under the United Kingdom flood defence programme. Current pledged funding amounts to US$279 million for disbursement over several years. This is an improvement over past delivery but still a fraction of what is required. It represents less than one-half of what the German state of Baden-Würtemberg will allocate to the strengthening of flood defences.

It is not just the lives and the livelihoods of the poor that require protection through adaptation. Aid programmes are also under threat. We estimate that around one-third of current development assistance is concentrated in areas facing varying degrees of climate change risk. Insulating aid budgets from that risk will require additional investment of around US$4.5 billion. At the same time, climate change is contributing to a diversion of aid into disaster relief. This has been one of the fastest-growing areas for aid flows, accounting for 7.5 percent of total commitments in 2005.

Estimating the aid financing requirements for adaptation is inherently difficult. In the absence of detailed national assessments of climate change risks and vulnerabilities, any assessment must remain a 'guesstimate'. Our 'guesstimate' is that by 2015 at least US$44 billion will be required annually for 'climate proofing' development investments (2005 prices). Building human resilience is another priority area.