World Wide Views

Information booklet

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Read more about the project and the partners on www.wwviews.org.

Authors and editors

Ebbe Sønderriis, science journalist
Lars Klüver, director, Bjørn Bedsted, Søren Gram and Ida Leisner, project managers, The Danish Board of Technology

English proofreading

Karen Mohr Sokkelund

Layout

Eva Glejtrup, Project Secretary, Danish Board of Technology

Photos

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Introduction

Welcome to World Wide Views on Global Warming

We have invited you to take part in World Wide Views because political leaders need to learn about your views on what should be done about global warming. We look forward to hearing your opinion and making your views known to decision makers and to the public.

Global warming has impacts for almost all people around the world. We are already experiencing climate change in all continents and changes in weather that could be a result of global warming. Our children and grandchildren may live to experience more dramatic consequences of global warming. It is the politicians who determine the future of the planet, but you, as a citizen will have to live with the consequences of the decisions made by the politicians.

Therefore, your opinion is important.

At the World Wide Views meeting you will share your views with fellow citizens. This booklet provides basic information about climate change and policy issues, along with different points of view regarding climate change and possible actions. It will serve as common ground for the discussions at the World Wide Views meeting.

The focus of the information booklet is on issues which will be negotiated at the Copenhagen Climate Conference in December, 2009.

Science informs us. It does not tell us what to do. The choice is ours. Have your say.

How to read the document

We have tried to use simple language; however, the issues are complicated. If you find the paper too long, you can take a glance at the pages and read the summaries in **bold** letters below each headline.

The paper has four parts. The first part is a general introduction to climate change and its consequences. It explains the current and future impacts, causes, and risks. What is climate change? Is it caused by humans? What is the greenhouse effect? What is known about the impacts of climate change in different parts of the world? Are there risks of global warming getting out of human control?

The second part is about international climate treaties and the agenda of the Copenhagen Climate Conference. What are the obligations of different countries? Which long term visions and goals have been proposed? How urgent is it to combat climate change? How urgent is it to reach a new climate deal?

The third part is about how to deal with greenhouse gas emissions. How much and how fast should emissions be limited and reduced? What are different countries willing to do? Which targets have been proposed? How should the efforts be shared among developed and developing countries? What are the means to limit global warming? What are the costs and the benefits?

The fourth part is about the economy of adapting to climate change and preventing emissions of greenhouse gases. Should the price of using fossil fuels be raised? Which are the needs of

adaptation to climate change and transfer of clean technologies? How should adaptation and transfer of technologies be funded and financed?

Scientific knowledge

Scientists all over the world have worked for many years to explore all aspects of climate change and to figure out how much of the change observed is caused by human activity.

Scientists also work hard to make clear what we actually know and what we do not know so we can all make informed decisions about what to do.

The Intergovernmental Panel on Climate Change, IPCC, is the authoritative source to such knowledge. It was formed by decision of the UN General Assembly in 1989 to provide scientific advice for decision-makers. The IPCC regularly examines and assesses the scientific contributions of thousands of scientists. The main conclusions are approved by scientists and by government representatives as well. Membership to the IPCC is open to all countries member to the World Meteorological Organisation and the UN Environmental Programme.

According to the IPCC, global warming is undeniable. It is very likely (more than 90 percent certain) that most of the warming observed since 1950 is caused by human-made greenhouse gases. Future climate change can be described only within a range of uncertainty.

If the 192 parties to the UN climate treaties opt for limiting global warming below 2 degrees Celsius, as a majority of countries say they do, IPCC tell us that the trend of growing greenhouse gas emissions must be reversed within a few years.

This paper largely builds on the latest assessment report from the panel, published in 2007. The wordings and simplifications; however, are solely our own responsibility.

How this document was produced

The information booklet has been written by science journalist Ebbe Sønderriis in close cooperation with the Danish Board of Technology, coordinator of World Wide Views. A Scientific Advisory Board has been established to review whether the information gives the background knowledge necessary to form opinions on the questions, to avoid misunderstanding and to ensure a relevant balance of information.

To test if the information was relevant, well balanced, and easy for lay people to understand, four focus group interviews were carried out, in Japan, in Canada, in Denmark and in Bolivia. All World Wide Views partners have been engaged in commenting drafted versions of the information booklet.

Copenhagen June 2009

Contents

1. Climate Change and its Consequences

What is global warming?

Global warming means that surface temperatures at average are rising all over the world. As a consequence, more ice is melting and sea levels are rising.

The warmest years on record since 1850 are 1998, 2005, 2003, 2002, 2004, 2006, 2007, 1997 and 2008.

Because of the warming, the extent of sea ice is shrinking, especially around the North Pole. One of the big ice shelves close to Antarctica has disintegrated. Mountain glaciers in most parts of the world are receding.

When the water of the oceans gets warmer, it expands; therefore, sea levels are rising. The sea level rise will continue for many centuries as heat spreads to lower and colder waters. Melt water adds further to sea level rise as more ice is melting in glaciers and ice caps.

What is climate change?

Climate is the long-term patterns of weather. Because of global warming the patterns change. The changes affect man and nature in many ways. Some of the changes are slow, others are dramatic: more extreme weather events have occurred. They are likely to occur more often in the future.

All parts of the climate are connected to each other: temperatures at day and night, summer and winter, rain and snow, moisture, evaporation, drying, clouds, winds, sea currents, ice formation and ice melt… Global warming changes the conditions of life. Some benefit from rising temperatures. Others have difficulties to adapt.

The climate of the Earth is an energy system powered by the sun. Global warming means more energy in the system; therefore, many weather events become more powerful. Extreme weather events happen more often. Examples are:

- Heat waves with higher temperatures occur more often.
- Droughts become more frequent, more widespread or enduring.
- Rainfalls and snowfalls become heavier or more frequent.
- Storms become more intense

It is not possible to single out one extreme weather event saying: "It happened because of global warming. If there were no global warming, it would not have happened."

Nor is it possible to predict future extreme weather events (how much, how soon and where). But the pattern is clear, climate science says: many extreme weather events are more common now than they were before. They are expected to occur more and more often in the future.

Negative impacts of climate change

Millions of people are in danger from sea levels rising and extreme weather events. Supply of food and water are at stake. Some people experience health problems. Some people loose their home and property. Some plants and animals cannot adapt to the changes. Ecosystems change.

The possible impacts of climate change depend on where you live. They also depend on the capacity of people and countries to cope with the changes. Poor people in poor countries are the most vulnerable. They can't afford to buy new things to compensate for their losses. They usually depend on traditional ways of living, local crops, and the gifts of nature for food and shelter.

Flooding and storms
Many people live in low-lying coastal areas, river deltas, islands and coastal cities. Their living conditions and subsistence will be influenced from rising sea levels combined with storms and heavy precipitation if the pattern of climate change continues.

In recent years flooding has become more frequent in many regions.

Devastating storms have become more intense in the Caribbean and the United States. Intense tropical storms in other parts of the world, such as South and East Asia, are likely to become more frequent as global warming continues.

Some low-lying island states are in danger of extinction because of sea level rise combined with heavy weather.

Drought and water shortage
Many dry areas are expected to become even drier. Water becomes scarce in many regions, such as northern Africa, southern Europe, and part of the Middle East, western United States, southern Africa, and the north-eastern Brazil.

When the rain comes, it often is short and heavy.

Ice melt also causes water shortages: Himalaya is called 'the water tower of Asia'. Many large rivers including Indus, Ganges, Mekong, Yangtze and the Yellow River have their sources in the Himalayas and the Tibetan Plateau. 1.3 billion people depend on these rivers for irrigation of their fields and for freshwater.

Now the mountain glaciers are melting and as they disappear, the water comes more suddenly in springtime, causing flood problems. Sometimes in Nepal and Tibet the water even comes as great floods when glacial lakes barred behind banks of gravel and ice break through their barriers.

Climate Science and Uncertainty

Science has detected the human influence on climate at each continent. Though on smaller scales, such as specific countries for shorter periods, science can only tell us about patterns and trends.

Some of the factors driving climate change are still poorly known. As a result future climate change can be described only within a range of uncertainty. At best estimate a doubling of greenhouse gas concentrations will result in an average temperature rise of 3 degrees Celsius - but the range of uncertainty is 2 to 4.5 degrees. It is not possible to say exactly what will happen and where it will happen, if global warming reaches a certain level. Science can tell us about the likely effects of such warming and the options, we have.

The latest assessment of the UN climate panel, IPCC, says that greater and irreversible changes with significant impacts are in store, if we continue to emit greenhouse gases. The report also says that the reasons for concern now are stronger than previously thought. The evidence of the impacts and risks has increased.

Since the report was published, many climate scientists have found that climate change is even more serious. Few if any have published results showing the opposite.

In the summer time, on the other hand, millions of people along the great rivers run short of water because the usual steady stream of melt water fails to come.

The same pattern is seen in the Andes, where a lot of people depend on melt water. Glaciers are shrinking at a fast rate. The water supply for Lima, the capital of Peru with 8 million inhabitants, is at risk within 20 years.

Food shortage
In tropical countries and regions with a dry season some of the traditional major crops will yield less as temperatures rise 1 to 2 degrees Celsius. Climate change also affects the stocks of fish in different waters and the grazing conditions of livestock.

The risk of food shortage first hits the smallholders, subsistence farmers, pastoralists and artisanal fisher folk. They have little capacity to change and a high vulnerability to extreme events.

Many countries in Africa south of Sahara are hit because climate change adds to their problems with poverty and malnutrition.

Health problems
The World Health Organization estimates that climate change contributes to 150,000 deaths each year, half of which are in Asia-Pacific. People become ill or are injured because of heat waves, fires, droughts, floods, and storms. Mosquitoes appear in new places, bringing malaria and dengue fever. Shortage of freshwater increases the risk of waterborne diseases. As temperatures rise, the burden from malnutrition, diarrhoea, heart and lung diseases, and infectious diseases increase.

The negative health effects are greatest in low-income countries. Urban poor, the elderly and children, subsistence farmers and coastal populations are at greatest risk. However, events have

shown that even high-income countries are not well prepared to cope with extreme weather events. The health risks are projected to grow in all countries.

Effects on nature (ecosystems)
Natural organisms live interconnected in complex balanced systems. When the temperature rises and weather patterns change, the balance of the ecosystem can be disturbed. Pests can thrive. Some species may not be able to adapt to the changes and become extinct. This in turn can make it impossible for other species who depend on them to survive.

One of the effects of global warming is the bleaching of coral reefs – often called the 'rainforests of the seas' because of their rich diversity.

In regions with dry seasons, the risk of wildfires increases.

International tensions
As droughts and water shortage become more frequent, along with loss of land and property, there is a growing risk of armed conflicts. This may also force more people to seek protection as refugees, which again can contribute to international tensions.

Positive impacts of climate change

Many people in relatively cold countries prefer a mild climate and will prosper from it. Expenses for heating of buildings diminish. In areas with sufficient water and nutrients, the crops yield better as temperatures rise and the growing season becomes longer. Forestry will have the advantage of faster growing trees. The warming also benefits the health of people in some regions.

The benefits are unevenly distributed, just like the adverse effects of global warming. In the 'colder countries', the so-called temperate zones, it is virtually certain that crops will yield better and forestry will benefit. Expenses for heating buildings during long and cold winters will fall. Less frost and fewer snowstorms will make roads and transportation more reliable in winter and decrease costs. Reduced exposure to low temperatures will also benefit the health of some people. Some regions are expected to become wetter, which can help reduce water shortages.

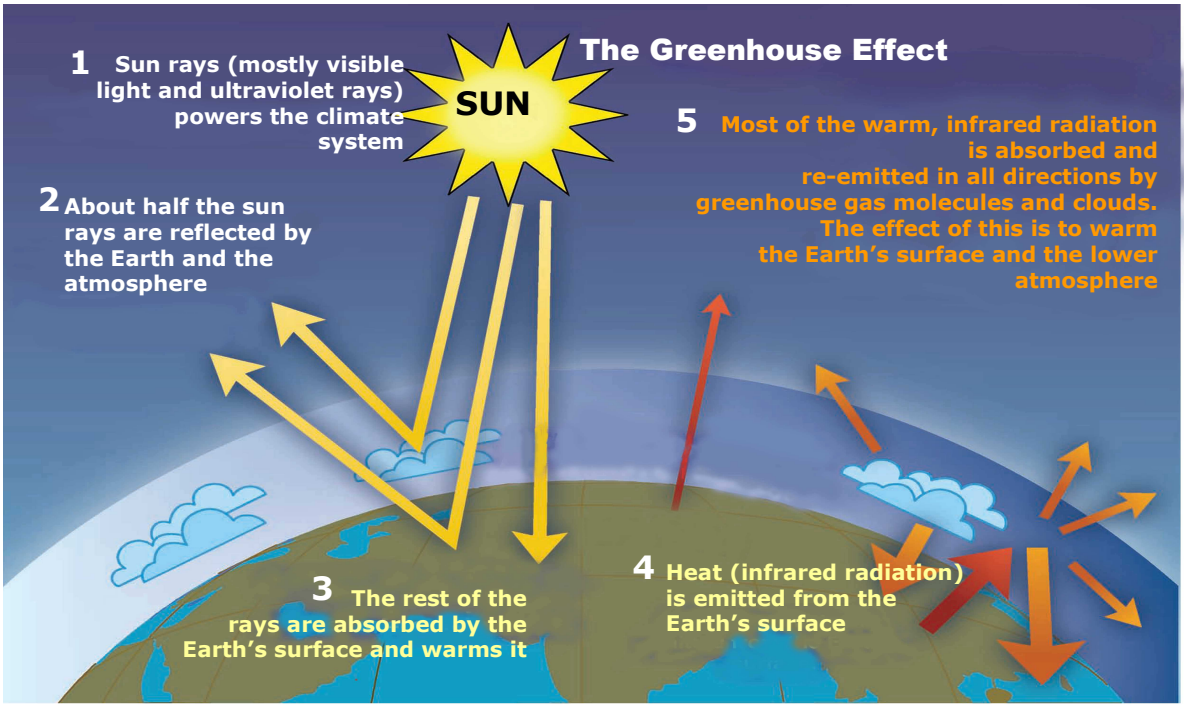
These benefits occur mainly in the United States and Canada, Northern Europe and northern Asia.

Whether or not these benefits will be outweighed by new risks such as thriving pests and extreme weather, diminished water supply in some areas, higher cooling expenses in summertime, etc. depends on many factors. Globally, the benefits of increased global warming will peak and fall as temperatures rise, whereas the costs will grow over time.

What is the greenhouse effect?

The atmosphere contains greenhouse gases. They function like the roof of a greenhouse: trapping the heat and keeping the Earth warm. The balance between energy coming from the sun and energy leaving the Earth is finely tuned. Human made greenhouse gases changes this balance. More heat is trapped – and the Earth gets warmer.

The most important greenhouse gas produced by humans is CO_2. Because of human activity, the concentration of CO_2 has grown by one third.



Inside a greenhouse it is warmer than outside, because of the glass roof. The roof lets the sunrays pass through but it traps some of the heat.

Greenhouse gases in the atmosphere work in a similar way for the Earth. When the sun shines on the Earth, most of the sun rays pass right through the atmosphere and warms us. But when heat rays from the Earth try to escape into space, some of these rays are trapped by greenhouse gases.

This greenhouse effect keeps the Earth warm, which makes life as we know it possible. The energy comes to the Earth mostly in the form of visible light and invisible ultraviolet radiation from the sun. It leaves the Earth mostly in the form of heat (invisible, infrared radiation).

Before human activity altered the atmosphere, the concentration of CO_2 was about 275 ppm (parts per million). It means that there were 275 molecules of CO_2 per million of other molecules. You could compare it to the size of a shoebox in a bedroom or a suitcase in a bus. Not much, but enough to make the climate of the Earth fit for life.

The human made growth in CO_2 concentration started some 200 years ago, mainly because of the use of fossil fuels (see page 11). Today the concentration has grown to 385 ppm. It continues to grow as long as humans emit more greenhouse gases than nature can absorb.

Does human activity cause global warming?

Most of the global warming observed since 1950 is due to human made greenhouse gases. Scientists are now at least 90 percent sure that this is the case.

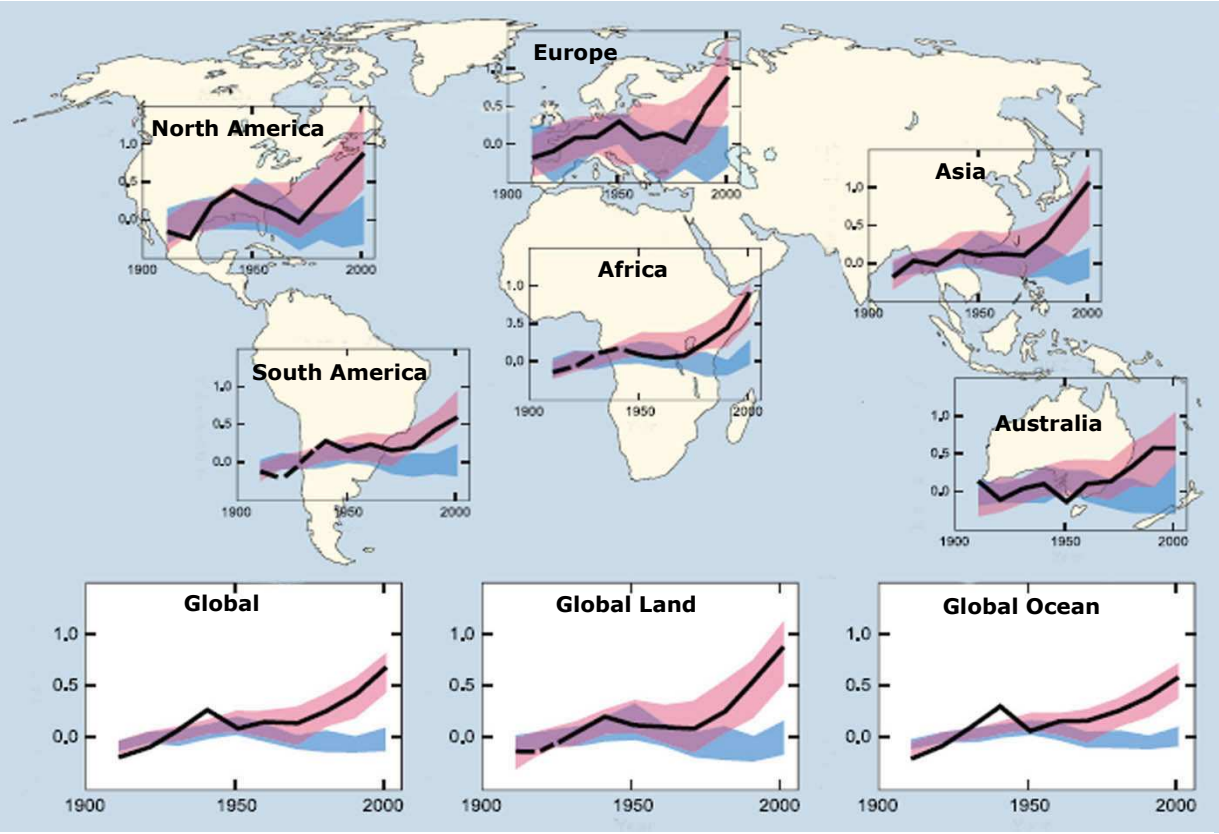
Below you can see how temperatures have been rising all over the world (black lines). Over the past 50 years, if there had been natural changes only (such as observed changes in the sun's radiation and eruption of volcanoes), there would have been a slight cooling instead of warming (dark shaded bands). When the effects of human activity are taken into account (light shaded

bands), the climate projections fit the observed temperature increases. The human activity includes greenhouse gases (causing global warming), aerosols (for example floating pollution particles tending to cause cooling by reflecting sunlight), surface colours (dark surfaces absorb more heat), and others.

The remaining scientific uncertainties mostly concern the quality of measurements, the orders of magnitudes, and the factors influencing the climate.

Some scientists question that greenhouse gases are the most important driving force of global warming. They say that other factors such as cosmic rays and solar magnetism may play an important role in recent climate change. They have found some correlations but their theories do not account for the post-industrial temperature increase.

Such search for alternative explanations is normal and necessary scientific practise. Some of the ideas may in the future be proven right. The theories, however, are supplementary unless they can give better, more consistent explanations taking all known climate factors into account. Most scientist, even if they criticise some aspects of mainstream scientific consensus, agree that the greenhouse effect is real and that human activity causes global warming.



Black curves show the observed global warming. **Lower dark shaded bands** show the temperatures to would be expected if there wore no human influence. **Upper light shaded bands** show the temperatures expected when human influence is included. They fit with the observations. Without human interference a slight cooling would be expected instead of the warming observed.

Where do the greenhouse gases come from?

The main source of human-made greenhouse gases is the use of fossil fuels.

The most important greenhouse gases are carbon dioxide and methane. Their common element is carbon. Carbon is also the common element of coal, oil, and gas.

Carbon is not dangerous. On the contrary, it is part of life. There is carbon in all living things. The oceans, the soils, the forests, all living organisms contain carbon. All plants absorb carbon dioxide as they grow. When they wither, burn or decay, carbon is released as carbon dioxide or methane. This is part of the natural carbon cycle.

Coal, oil, and natural gas are made from plants that lived millions of years ago. They were covered with sand, chalk or other sediments. Trapped under high pressure some of them were transformed into coal others into plant material and combined with hydrogen to create oil and natural gas. In this way, large amounts of carbon have been captured underground until humans began mining and drilling for them.

When fossil fuels are burned and combusted in power plants, factories, buildings, cars, and other engines, the carbon is released. Today, nature can absorb only a fraction of this extra carbon. Deforestation adds to the problem because land is cleared and carbon is released much faster than new plants grow and absorb carbon elsewhere.

Agriculture also adds to the problem, depending on the way the land is used. For instance, when the number of cattle and cows is increased to produce more meat and milk, more greenhouse gases are released, since ruminants make methane when digesting. Much more land, plant protein, and energy is used to feed animals than for the production of plant crops.

Organic waste adds further greenhouse gases, except if the waste is recycled or if methane from waste dumps is recovered.

Do greenhouse gases disappear?

Once emitted to the air, carbon dioxide does not disappear. Some of it will stay in the atmosphere for thousands of years, continuing to cause warming. Due to this warming trend, sea levels will continue to rise for hundreds of years.

Growing plants and sea water can absorb some of the extra carbon dioxide, but not as much as released by the burning of fossil fuels and clearing of forests.

There are two opposite tendencies: In some parts of the world, when water and nutrients are sufficient, young plants grow faster and absorb more carbon dioxide when the climate gets warmer. In other parts of the world, the soils, forests and oceans absorb less carbon when the climate gets warmer. Unfortunately, the second tendency is stronger than the first one.

Today the global emissions of greenhouse gases are **growing** at a fast rate.

If emissions were kept **constant** at current rates, the amount of greenhouse gases present in the atmosphere would continue to grow because more greenhouse gases are emitted than absorbed. As a result, global warming would accelerate.

Even if everybody **stopped** emitting greenhouse gases tomorrow, global warming would continue for many years. Gradually the concentration of greenhouse gases would diminish, but meanwhile,

the amount of greenhouse gases present in the atmosphere would continue to trap heat. The warming would slowly spread, especially to the deep water masses of the oceans.

That's the difference between the global greenhouse and the greenhouses used by gardeners: in the global greenhouse, there is no window that you can just open to let cool air in from the outside. We can only reduce the thickness of the cover of greenhouse gases.

Risks at rising temperatures

If emissions of greenhouse gases continue at present trends, the world is on track for a warming of more than 4 degrees Celsius. The negative impacts will grow and the benefits of positive impacts will diminish as temperatures rise. Heat and sea levels rise, flooding, intense storms, drought, water shortage, food shortage, health problems and damage to ecosystems will increase. The risk of permanent damages and self-enforcing climate change will grow.

Different future scenarios assessed by the UN climate panel, IPCC show that global warming will accelerate if emissions continue at present trends. Many different assumptions can be made about future world population, economic growth, fossil fuel prices and technologies. The likely range of future warming is between 4.0 and 6.1 degrees Celsius in the high emission scenarios assessed by the IPCC. The upper boundary is less certain than the lower boundary.

The growing impacts will create new problems. For example when drought or flooding happens more often and has a greater extent, more people will be forced to leave their home and seek protection as refugees.

Some of the impacts are shown on the figure below. The impact is growing as temperatures rise. As you can see from the figure, many effects have already begun. This includes: a lack of water and increased drought problems in several regions; negative impacts on the production of food among some smallholders, subsistence farmers and fishers; damage from floods and storms in some coastal areas; health problems, wildfire risks, and coral bleaching.

It is expected that the yield of some crops will begin to decline in tropical countries even when warming is only 1.5 degree Celsius, and that the productivity of all crops in tropical countries will decrease if warming reaches about 4 degrees Celsius. Millions of people could experience flooding each year at a global warming of about 3 degrees. At about 4 degrees a substantial part of global wetland along the coasts could be lost. The extra burden on health services is substantial for global warming at about 4 degrees Celsius.

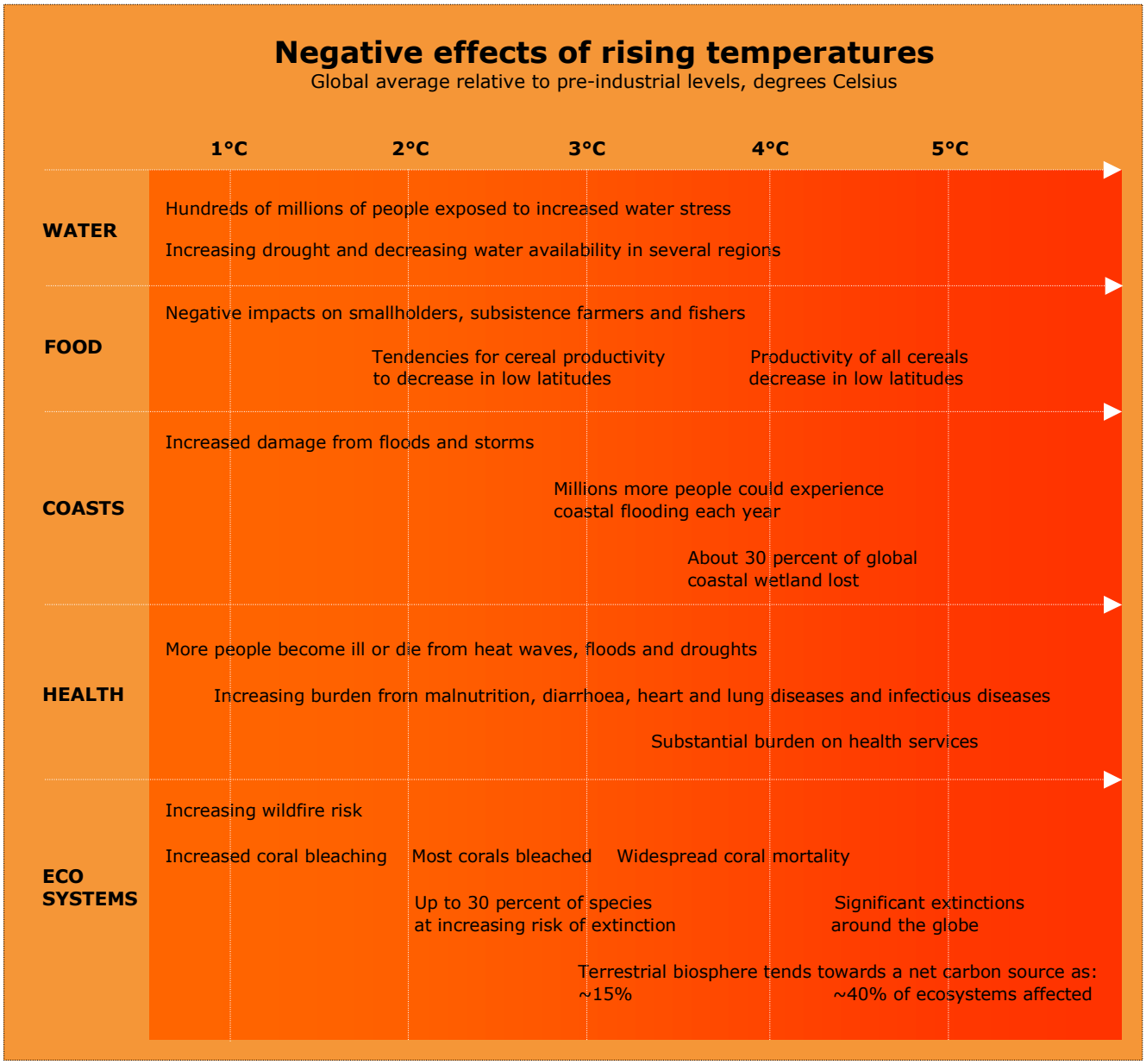
Some damages cannot be repaired. Once a species or a coral reef is extinct, it cannot be brought back. Once a desert is formed, it is very difficult to make it blossom again.

As long as global warming continues, this risk will grow. A warming of more than 2 degrees Celsius is expected to put up to 30 percent of species at risk of extinction. A warming of 4-5 degrees probably means significant extinctions and loss of biodiversity around the globe.

Once fertile land is degraded and changed into desert, it seldom can be regenerated. Once coastal areas are eroded and lost to the sea, it seldom can be recovered.

Such changes are irreversible.

Climate change in itself triggers further changes, which can reinforce the impacts of global warming.



Melt of sea ice and snow cover
A dark surface, as most people know from their own experience, absorbs more heat than a light surface. When sea ice and snow cover disappear because of global warming, the darker surface of the sea and the land absorbs more heat, leading to even more warming.

Melt of ice caps
Ice caps were formed during an ice age. When the ice caps start melting in a warmer climate, the process is self-enforcing. The ice formed and the ice lost does not outweigh each other. The glaciers move faster. In the absence of a new period of climate cooling or extra snowfall, the whole ice cap will inevitably melt. If it happens to the Greenland ice cap, the result will be a 7 metre (23 feet) rise of global sea levels. It did happen to other ice caps at the end of the latest ice age. It is not known how much warming triggers this process. It may be happening right now. Nor is it known how fast the process will be. It may take several hundred years.

Change of sea currents
Cold water with a high content of salt is heavier than warmer surface water. The great sea currents of the oceans are driven by this difference. Heavy water sinks towards the bottom of the oceans along the Arctic and the Antarctica. Warm water is attracted from the tropical seas to replace it. All simulations agree that these currents will become weaker because of global warming. As a consequence, the warming will increase in tropical areas.

The oceans become sour
When there is more carbon dioxide in the air and the oceans therefore absorb more of it, they become more acidic. This is a problem for corals and all other shell forming organisms, as it weakens the ability of oceans to further absorb carbon dioxide.

Release of methane when the tundra thaws
The permanently frozen ground in the far North (Alaska, Siberia, and other places) has begun to thaw because of higher temperatures and darker surfaces. Some local societies are threatened because houses and roads are built on the frozen ground. An enormous amount of methane is tied up in the soils and lakes of the tundra. Some of it is released when the tundra thaw. This can accelerate global warming.

Heat and drought in the rainforest
More heat and less rain harm the rainforests. The worst drought in 100 years hit Amazonia in 2005. The eastern part of Amazonia is expected to be dry like the Savannah of Africa by mid-century. Meanwhile, a lot of carbon will be released from withering trees and from the soil. Because the rainforests contain a big part of the world's carbon, such a self-enforcing mechanism could boost the global warming much more than man-made deforestation.

Examples of impacts in different regions

The impacts of climate change vary according to local conditions. Below are some examples of the impacts to be expected in different regions of the world if greenhouse gas emissions continue at or above current rates. For temperature increases of 1- to 3.5 degrees Celsius some of the impacts are projected to produce positive impacts in some places and negative impacts in other places. The negative impacts are worst in tropical, subtropical and polar regions, while positive impacts are more common in temperate regions. At about 2.5 to 3.5 degrees, it is very likely that all regions will experience declining net benefits or increasing net costs. At about 4.5 degrees, global mean losses could be 1 to 5 percent of global Gross Domestic Product, with larger percentages in developing countries. Adaptation to climate change is costly. Net benefits mostly occur in wealthy countries in Europe, North America and Asia, southern Latin America and some places in Australia and New Zealand. These countries often are in a position to finance the adaptation needed. Poor countries will need financial aid to do this.

Africa
In Africa where the Niger River has already less water than before, 75-250 million people are projected to suffer from increased water shortage by 2020. The yield of rain-fed crops could be halved in some African countries. This is expected to cause severe food problems for many millions of Africans. By the end of the century, large populations living in low-lying coastal areas are at risk to be severely affected at further sea levels rise. The cost of adaptation could amount to at least 5-10 percent of economic output per year.

Asia
By mid-century less freshwater is projected to be available in Central, South, East, and South-East Asia, particularly in large river basins. In South, East, and South-East Asia the heavily populated mega deltas will be at greatest risk due to increased flooding. In the same regions diseases associated with floods and droughts, such as diarrhoea, are expected to cost more lives. The pressure on natural resources and the environment due to rapid growth of cities, industries, and economies are projected to be aggravated by climate change.

Australia and New Zealand
In ecologically rich sites like the Great Barrier Reef and Queensland Wet Tropics significant loss of biodiversity are projected to occur by 2020. By 2030, water security problems are expected to be aggravated in southern and eastern Australia, in Northland and some eastern regions of New Zealand. Production from agriculture and forestry is projected to decline over much of southern and eastern Australia and over parts of eastern New Zealand, due to increased drought and fire. Initial benefits from global warming are however projected in some other parts of New Zealand. By 2050, ongoing coastal development and population growth in some areas are projected to increase the effects of sea level rise and more frequent and severe storms and flooding.

Europe
Differences in natural resources and assets between different parts of Europe are expected to be magnified. Increased risk of inland flash floods, coastal flooding and erosion are among the negative impacts. Mountain areas face glacier retreat, less snow and winter tourism, and loss of species (in some areas up to 60 percent by 2080, if emissions remain high). Southern Europe is already vulnerable to climate change; high temperatures and drought is projected to reduce water availability, hydropower, summer tourism and, in general, crop productivity. Health risks due to heat waves and wildfires are projected to grow.

Latin America
In eastern Amazonia by mid-century, the tropical forest is projected to be replaced gradually by savannah (less trees, more grass) because of more heat and less moisture in the soil. There is a risk of significant loss of species and biodiversity in many parts of tropical Latin America. Productivity of some important crops and of livestock is projected to decline. In areas with a temperate climate, soybean yields are projected to increase. Disappearance of glaciers and change of precipitation patterns are projected to cause water scarcity.

North America
In the western mountains already overused water resources are projected to strained because of less snow, more winter flooding and reduced summer flows. Yields of rain-fed agricultural crops are projected to grow by 5 to 20 percent in the early decades of this century in some parts of the region. Cities that currently experience heat waves are expected to be challenged by an increased number, intensity, and duration of heat waves during the century – with possible negative health effects. Coastal communities and habitats will be increasingly stressed by climate change impacts.

Polar Regions
In the Arctic, climate change is happening faster than elsewhere. Shrinking of sea ice, reduction of glaciers and icecaps will have detrimental effects on many organisms including migrating birds, seals, ice bears and other mammals and higher predators. It also will have detrimental effects on traditional ways of life. For human communities in the Arctic, the impacts are projected to be mixed, depending on the aspirations of people and their way of living. Permafrost thaw combined with other climate changes has negative impacts on buildings and roads and other infrastructure. In some places wildlife is projected to be vulnerable to invasion of other species when climate barriers are lowered.

Small islands

The rise of sea levels is expected to aggravate the effects of inundations, storm surge, erosion and other coastal hazards. This will threaten the livelihood of people living there because their settlements and vital roads and infrastructure will be hit. Local resources are expected to be affected by coastal erosion, coral bleaching, etc. By mid-century, water resources in many Caribbean and Pacific islands are expected to be insufficient to meet demand during low-rainfall periods. With higher temperatures, increased invasion by non-native species is expected to occur, particularly in non-tropic islands.

2. Long-term Goal and Urgency

Proposed long-term goals

By joining the UN Climate Convention, adopted in Rio de Janeiro 1992, most countries have agreed to prevent dangerous human caused climate change. It is up to governments to decide what that means. How much should the temperatures be allowed to rise, compared to the levels of pre-industrial times, before large scale use of fossil fuels began? A limit of 2 degrees and a limit of 1.5 degrees have been proposed. At present the warming is 0.8 degrees.

Almost all countries of the world are Parties to the United Nations Framework Convention on Climate Change. The convention is an international treaty. It was adopted in Rio de Janeiro 1992. The purpose of the convention is to prevent dangerous human made climate change.

Governments, world leaders and the citizens of the world have to define, what 'dangerous' means. The answer depends on the risks they are willing to run. Science can inform us about the possible consequences of climate change. It can tell us about the risks and the costs, the means to adapt to the changes, and the means to avoid some of them, but science is not able to tell us what the right decisions are.

In 2007, the parties of the Climate Convention met in the Indonesian island Bali. They agreed on an action plan and a road map for international climate negotiations to reach a new deal in Copenhagen in December 2009.

The Bali Action Plan says that deep cuts in global emissions will be required to address climate change. It calls for a shared vision for long-term cooperative action. Since then different long-term global goals for emission reductions have been proposed.

More than 100 countries have said they support a goal of limiting global warming to 2 degrees Celsius above pre-industrial level. 40 of the most vulnerable countries have said that such a level is not safe enough. They propose a temperature increase limited to below 1.5 degrees. A few nations do not want limitations.

Science has given us precise answers and robust conclusions… We now know the serious impacts of climate change, which would accrue as a result of inaction.

The record of global action at mitigation has been very weak, even though the UN Framework Convention on Climate Change was agreed upon in 1992. The record goes against the spirit and intent of the Convention…

We in the Intergovernmental Panel on Climate Change do not prescribe any specific action, but action is a must.

Rajendra K. Pachauri
Chair, IPCC

Two degrees Celsius is really not a safe level for small island states. For many of them it would be like a death sentence in the long run.

Leon Charles
Chair, Association of Small Island States

The Climate Convention and the Kyoto Protocol

The Climate Convention says that all countries have a shared responsibility to prevent climate change according to their capacities on the basis of equity.

In Kyoto in 1997, a protocol was added to the convention called The Kyoto Protocol, which sets binding targets for developed countries. The so-called Annex I countries (see box below) must limit their emissions of greenhouse gases by 2010 (2008 to 2012) compared to 1990 levels.

Countries can trade their emission allowances (carbon trade). A country can emit more than its target if it buys allowances from other countries that emit less than they are allowed to. A country can also make projects to reduce emissions in other countries instead of reducing its own emissions.

If a country does not meet its target – one way or another – the punishment is a 30 percent extra reduction during the next 5 years commitment period plus exclusion from international carbon trade.

The Climate Convention and its Protocol certainly have generated a lot of projects and efforts; however, global emissions continue to rise.

Most human caused greenhouse gases have come from developed countries. Developing countries with fast growing economies today have high emissions. Important emissions also come from big tropical forest countries. The 47 least developed countries have very small emissions only. But poor people, especially in developing countries, are hardest hit by climate change. The climate problems can be solved only if all these countries cooperate.

That is why the Climate Convention states the principle of common but differentiated responsibilities:

»The parties should protect the climate system for the benefit of present and future generations of mankind, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capacities«

(Article 3 of the Climate Convention).

In accordance with this principle, it was decided in 1992 that the developed countries should take action first. The industrialised countries of Europe, the former Soviet Union, USA, Canada, Japan, Australia and New Zealand were listed in Annex I to the Convention. These countries committed to bring their emissions of greenhouse gases down to 1990-levels by the end of the century (year 2000). But most of these emissions continued to grow - with the exception of the countries of the former Soviet Union and Eastern Europe, the United Kingdom and Germany. In most cases, reductions were due to political change and economic crisis rather than climate polities.

Annex I Countries

In climate talks, developed countries are defined in Annex I to the Climate Convention. They are:
Australia, Austria, Belarus, Belgium, Bulgaria, Canada, Croatia, Czech Republic, Denmark, Estonia, European Union, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Latvia, Liechtenstein, Lithuania, Luxembourg, Monaco, Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom, the United States of America (not a member to the Kyoto Protocol).

The parties realised that further obligations were necessary to prevent dangerous climate change. They met in Kyoto in 1997, the former imperial capital of Japan, and agreed to add a protocol to the Convention.

The Kyoto Protocol sets binding targets: During the first commitment period (2008-2012), the Annex I countries are to reduce their emissions by an average of 5.2 percent compared to 1990

levels. The United States are not bound by its target, as they decided not to ratify the Protocol. Developing countries have no binding obligations to reduce their emissions.

The Kyoto Protocol invented carbon trading. A country that does not meet its target can buy emission allowances from other Annex I countries that emit less than they are allowed to. A country can also achieve emission allowances by investing in projects in other countries, including developing countries. The purpose of these market-based mechanisms is to make reductions happen wherever they can be made at lowest costs.

If a country emits more greenhouse gases during the first commitment period than its assigned amount, it is required to make up the difference in the next commitment period, plus an additional 30 percent. In addition, the right to take part in emissions trading is suspended.

The compliance regime is strict compared to most other multilateral environmental agreements; however, some people advocate for stricter rules. The international trade system, for example, governed by the World Trade Organisation, allows for trade sanctions if a country does not comply with trade rules. Another option is to impose fines, making it costly not to meet the targets.

The Climate Convention and its Protocol have succeded in generating a lot of projects and efforts. For example, carbon trade has been tested and developed, research and development have been intensified, and technologies have been invented and more widely used. Public awareness about climate change has grown too. Energy efficiency has grown too and some reductions of greenhouse gas emissions have been achieved.

However, global emissions continue to rise. The vast majority of countries have found that the achievements are not sufficient compared to the challenges. They decided in Bali, in 2007, that a new climate deal should be made.

Urgency

In Bali, in 2007, the governments of the world decided a new climate deal is urgently needed. Proponents claim that time is running out if we wish to limit global warming to less than 2 degrees Celsius – and if we wish to make a new deal work before the old one expires. Critics prefer governments to wait for more scientific evidence and cheaper technologies before making strong commitments.

Three reasons for urgent action were forwarded by the 192 parties meeting in Bali. The first is the wish to stabilise the climate at a relatively low level of warming. The science assessed by the UN climate panel, the IPCC, shows that it may be possible to limit global warming to about 2 degrees Celsius or less if action is taken within a few years. If action is postponed so that world emissions do not stop rising within about ten years, the chances of limiting global warming to such a level will become quite slim.

The second reason for urgency is to make a new deal before the present Kyoto-commitments expire by the end of 2012. It takes years for an international agreement to enter into force and to be implemented in all countries. The Kyoto Parties said they want a new agreement this year in order to avoid a time-gap.

The third reason is that the countries bound by the Kyoto Protocol want to get other countries involved as soon as possible. Many nations with high emissions have not yet taken legally binding obligations. Among these countries are the world's leading emitters, China and the United States.

In each country however, the urgency is subject to discussion. There are 'climate change deniers' who claim that global warming is not real. Others believe that climate change is happening, but that is not caused by human-made greenhouse gases. They therefore do not consider a new climate deal to be urgent or relevant. Some 'climate sceptics' claim that certain parts of climate science get the data wrong, that the causes of change are misunderstood, or that concerned scientists draw 'alarmist' conclusions. Some sceptics also say that their colleagues exaggerate the role that humans play in causing climate change.

Sometimes the debate becomes very heated. Climate sceptics have claimed that their research is obstructed by mainstream scientists or authorities. Environmentalists have claimed that climate sceptics are paid and tampered by the oil industry. The assessments of the UN climate panel, the IPCC, do not exclude the sceptics, since the IPCC-principle is to take into account all peer reviewed scientific results.

Yet other critics think that scientific uncertainty should be further reduced before action is taken. Some of them argue that it is too expensive to reduce emissions at short notice. They expect the price of alternatives to the use of fossil fuels to fall, compared to gross economic output in the future.Several environmental organisations have warned against making a climate deal with low targets for reductions and limitations of emissions. They would prefer not to have a deal at all if targets are set too low.

If humanity wishes to preserve a planet similar to that on which civilization developed and to which life on Earth is adapted, paleoclimate evidence and ongoing climate change suggest that CO_2 will need to be reduced from its current 385 ppm to at most 350 ppm.

An initial 350 ppm CO_2 target may be achievable by phasing out coal use except where CO_2 is captured and adopting agricultural and forestry practices that sequester carbon.

If the present overshoot of this target CO_2 is not brief, there is a possibility of seeding irreversible catastrophic effects.

Dr. James Hansen:
Where Should Humanity Aim?

350.org

James Hansen of the NASA Goddard Space Institute is a veteran of climate science. He has come to the conclusion that emission of greenhouse gases must be lower in the future than they are today. »I do not want my grandchildren to say: He knew about it but he did nothing«, he says.

The organization 350.org try to unite people and organizations around the 350-goal for concentration of CO2 in the air. »Make no mistake«. it says. »Getting back to 350 means transforming our world. It means building solar arrays instead of coal plants, it means planting trees instead of clear-cutting rainforests, it means increasing efficiency and decreasing our waste. Getting to 350 means developing a thousand different solutions – all of which will become much easier if we have a global treaty grounded in the latest science and built around the principles of equity and justice.«

350.org is supported, among many others, by archbishop Desmond Tutu, the Indian environmentalist Vandana Shiva, the American writer and acitivist Bill McKibben, the scientist and environmentalist David Suzuki, and the human rights advocate Bianca Jagger.

What's up in Copenhagen in December 2009?

All of the Parties to the Climate Convention and the Kyoto Protocol have pledged to reach a new climate deal in Copenhagen in December 2009. The aim is to agree on a shared vision for long-term action and on emission reductions to be reached by 2020. Also on the agenda are adaptation to climate change, transfer of technology, and funding and finance.

The Copenhagen climate meeting is the 15th conference of the Parties to the Climate Convention (known in short as COP15). At the same time, it is a meeting of the Parties to the Kyoto Protocol.

Nearly all governments of the world will be represented – along with many journalists and non-governmental organisations (environmentalists, business organisations, development organisations, UN-organisations, and many others).

We need a Green New Deal that works for all nations, rich as well as poor…
We urgently need a deal on climate change to provide the political, legal and economic framework to unleash a sustained wave of investment. In short, our response to the economic crisis must advance climate goals, and our response to the climate crisis will advance economic and social goals…

Industrialized countries must set ambitious long-term goals, coupled with mid-term emission reduction targets.

Developing countries need to limit the growth of their emissions, as well. To do so, they will need financial and technological support – not just promises, but tangible results. Change must be integrated with strategies for development and poverty alleviation. One without the other means failure for both…

We must break free of entrenched positions – who is to blame, who must act first. We are all in this together.

Ban Ki-Moon
Secretary-General, United Nations

Formal decisions cannot be made by a majority vote. Since the parties are independent nations, they will have to reach agreement by mutual understanding and consensus.

The purpose of the meeting is, as stated in the Bali Action Plan, to adopt a new global climate deal.

The parties will have to define:

- What danger-level of global warming is acceptable?
- How should efforts be shared (according to the principle of common but differentiated responsibilities)?
- Which actions should be taken by each party?
- Which means should be promoted and supported to limit global warming and adapt to climate change?
- What should be the rules and conditions of a new climate deal?

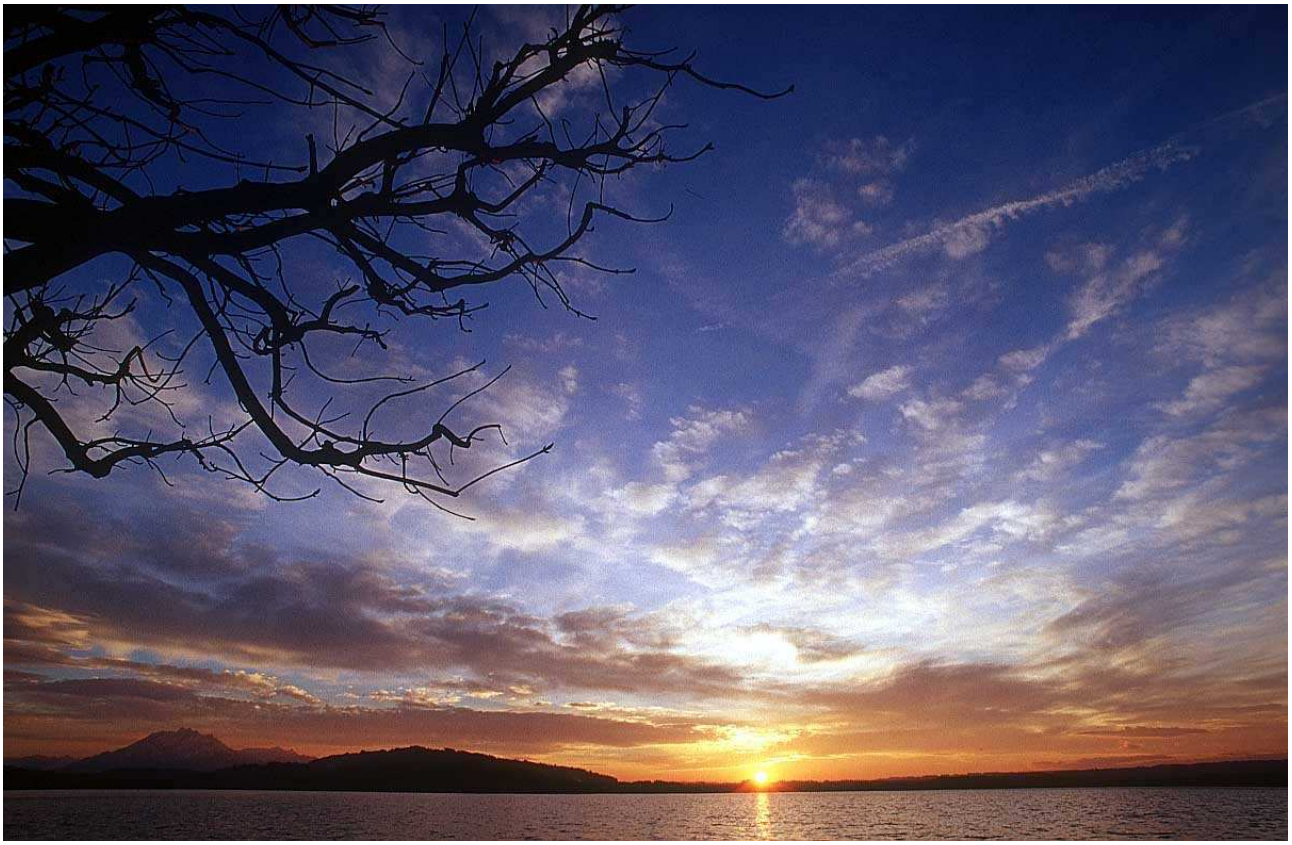
The main issues on the agenda are:

- **Shared vision for long-term actions.**
  Including global goals for emission reductions by mid-century.
- **Binding reduction targets.**
  Including the countries already Parties to the Kyoto Protocol as well as the USA and other countries with high emissions and high capacity to cut down their emissions.
- **Limitation of emissions**
  - from other countries, especially large middle-income countries with high emissions.
- **Adaptation.**
  Cooperation and support for building capacity to cope with the negative consequences of climate change.
- **Technology transfer.**
  Cooperation and support for development and fast transfer of climate-safe low carbon technologies.
- **Funding and finance.**
  As we have seen, rich countries have high emissions while poor countries are often the hardest hit by climate change. The conference will have to decide how to provide the financial means to fund adaptation and the spread of better technologies.

The battle against climate change can only be won “in the hands of the many, not the few” a top scientist has said…

There is just no way that we are going to be able to shift ourselves to tackle the fundamental problems of the crisis without addressing public participation

Jacqueline McGlade
Head of the European Environment Agency



3. Dealing with Greenhouse Gas Emissions

Emission pathways

Emissions have to peak and fall if we want to stabilise the concentration of greenhouse gases in the atmosphere. The UN climate panel, the IPCC, has assessed many studies of possible future pathways. It has found that there is a fair chance to limit global temperature rise by 2 degrees Celsius if global emissions peak soon and are more than halved by 2050.

The atmosphere above us is vast, but it is not infinite. As long as humanity emits more greenhouse gases than nature absorbs, the concentration of greenhouse gases will grow.

On the other hand, it is impossible to stop all emissions at once. To do so would be very costly and would harm many people. Imagine what would happen: No electricity, no heating, no transport, no production, and no construction works, except what is driven today by renewable energy sources or nuclear power. Most factories, ships, cars, aeroplanes, light bulbs, fans, air cons, heating systems, computers, and machines of any kind would stop working.

To stabilise greenhouse gases in the atmosphere, emissions must first be reduced, they will then peak and after that they should fall to a fraction of what they are today. Even so, temperatures will

not fall back to former levels. This will only stop temperatures from rising. The sooner emissions peak and fall, the lower levels of stabilisation can be achieved.

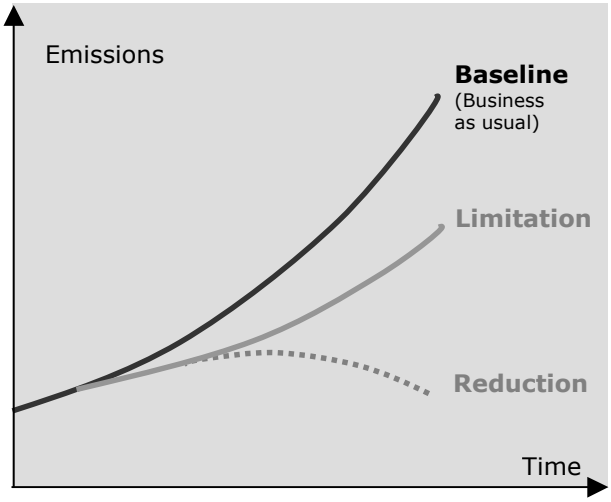
This is called an emissions pathway. The UN climate panel, the IPCC, has assessed almost 200 possible pathways. The IPCC found that a global warming of 2.0 to 2.4 degrees is the likely outcome if global emissions peak within six years and are reduced by 50 to 85 percent by 2050.

The latest pathway study was published in April 2009. It says that chances are 3 out of 4 to keep global warming below 2 degrees Celsius if the world emits 1000 billion tonnes of CO_2 from year 2000 to year 2050. More than a quarter of these 1000 billion tonnes has already been emitted. Today's world emissions are more than 50 billion tonnes per year, and still rising. A small calculation will show that world emissions have to peak soon and fall steeply after that in order to achieve stabilisation at 2 degrees.

It would take many years to see the full results of actions even if they are taken immediately. If, for instance, it is decided today to make new, much more efficient cars, then new models would have to be designed and tested first, automakers would have to build new factories, and customers would have to buy new cars and scrap the old ones before full effect of the action taken would be reached. To change electricity supply, change buildings or the use of cement and steel would take even longer.

Sharing the efforts

It has been proposed that developed countries reduce their emissions by 25 to 40 percent by 2020 and by 75 to 95 percent by 2050. It has also been suggested that developing countries limit their emissions to 15 to 30 percent compared to baseline to 2020 and to reduce their emissions by 25 percent compared to year 2000 by 2050.



To limit emissions compared to baseline means that emissions can still grow for awhile, though not as fast as they would if no additional measures were taken.

Once a long-term goal and an emission pathway have been defined, the next step is to agree on effort sharing. According to the principle of common but differentiated responsibilities, the developed countries should reduce their high emissions first, while developing countries should

limit the growing emissions without compromising sustainable development and alleviation of poverty.

In the preparations to the Copenhagen conference, a wide variety of proposals have been made. One proposal is that developed countries reduce their emissions by 'at least' or 'more than' 25 to 40 percent from 1990-levels by year 2020. By 2050 it has been proposed that developed countries reduce their emissions by 75 to 85 percent or by 'more than 95 percent'. Most proposals are in the same order of magnitude as the assessment of the UN climate panel, the IPCC, concerning a possible limitation of global warming at about 2 degrees Celsius above pre-industrial temperatures.

In negotiations between the parties to the UN Climate Convention and the Kyoto Protocol as we have seen, 'developed countries' are defined as Annex I countries only (see page 19). All other countries are named 'developing countries'.

In India, I need to give electricity for light bulbs to half a billion. In the West, you want to drive your Mercedes as fast as you want. We have 'survival' emissions, you have lifestyle emissions. You cannot put them on the same basis. I am trying to give a minimal commercial energy service, whereas you are not prepared to give up any part of your affluent lifestyle or give up consumption patterns.

Shyam Saran
India's special envoy on climate change
December 2008

For developing countries as a group, it has been proposed during the negotiations that their emissions should be 'significantly' or 'in the order of 15 to 30 percent' below their baseline by 2020. The proposals includes that these countries will be supported and enabled by technology, financing, and capacity building (see page 35) and that they can share the efforts amongst them.

By 2050 it has been proposed that the developing countries as a group reduce their emissions by 25 percent compared to year 2000.

Some proposals make explicit exception of the least developed countries.

Some of the countries that were not included in Annex I are countries with substantial economic income and/or high emissions. It is a central debate in the climate negotiations whether these countries should take on bigger commitments in a new climate deal to limit emissions, compared to developing countries in general. Some argue that if they don't, it will be impossible to limit global warming sufficiently, even if targets are set high for Annex I countries. Others argue that it is unfair to treat these countries differently from developing countries in general. Different criteria have been proposed in order to determine the obligations of individual countries. Proposals have been made to base the commitments on emissions per capita, emissions per country, historical responsibility and national income per habitant. A mix of these criteria has also been proposed.

Examples of Non-Annex 1 countries with substantial economic income and high emissions

Substantial economic income

Argentina, Bahrain, Belarus, Brazil, Brunei, Chile, Costa Rica, Israel, Malaysia, Mexico, Kuwait, Oman, Qatar, Saudi Arabia, Singapore, South Africa, South Korea, United Arab Emirates

High emitters

Argentina, Brazil, China, Egypt, India, Indonesia, Iran, Malaysia, Mexico, Saudi Arabia, South Africa, South Korea, Thailand, Turkey, Uruguay

This list includes countries with high emissions measured both by country and per person. The ranking of countries will look very different depending on which measurements are used.

Positions of developed countries

Compared to 1990, the level of present emissions varies greatly between different developed countries. The will of governments to commit to binding targets in 2020 also vary accordingly.

The Annex I countries with binding Kyoto-targets until now have very different records of emission reductions. In Eastern Europe, including Russia, emissions fell sharply in the years following 1990. Emissions are now on the rise in most of these countries. In the northern and western parts of Europe, emissions have been reduced, especially in Germany and Great Britain. In southern Europe, emissions have been rising. The European Union as a whole has reduced emissions. The rest of the Kyoto-countries (Canada, Japan, Australia and New Zealand) have had rising emissions. The United States has also had rising emissions. Emissions have been rising in high-income countries outside Annex I too.

The European Union has decided for itself to reduce emissions by 20 per cent in 2020, compared to 1990. In international negotiations, it offers a further reduction of ten percent if a strong new climate deal is reached. The common target for all developed countries should be a 30 percent reduction, the European Union says.

The United States aims to cut greenhouse gas emissions back to 1990-levels by 2020. If legislation presented to the US Congress pass, emissions may be cut somewhat more than that. Still, there is a gap of 20 to 25 percent between US targets and the 25 to 40 percent target mentioned by the IPCC and proposed by many countries.

The US Chief negotiator, Todd Stern, has said: »To insist on a 25 to 40 percent cut below 1990 for the United States is a prescription for stalemate«. Politics is the art of the possible, he argues. In the United States there is very little political support for such a deep cut (which would total be 40 percent in ten years).

»What counts is getting on a viable path between now and 2050… A somewhat steeper path in the latter period could make up for the slightly slower start« Todd Stern says. The United States aims to cut emissions by 80 percent by 2050.

Positions of developing countries

All non-Annex I countries say that developed countries must take the lead in emission reductions. The willingness of developing countries to take binding commitments to limit and subsequently to cut their emissions varies according to their capabilities and their wealth.

It is generally agreed that developing countries need economic growth and more energy supply to deal with poverty and the needs of growing populations.

On the other hand, some developing countries with high economic growth have the capacity to limit or reduce their emissions. Some areas in the so-called 'third world' have much industry, and many people with high incomes and high consumption. Even in poor countries, there are opportunities to reduce emissions at low cost.

The least developed countries cannot afford to use as much energy as they want to, be it fossil or renewable. Many developing countries, however, have put forward plans to curb the rise of greenhouse gas emissions, save energy, and become more energy-efficient.

In China, emissions have been growing very rapidly. They now emit more greenhouse gases than any other nation. China plans to curb the rise by reducing energy consumption per unit of economic output by 20 percent from 2006 to 2010 and to quadruple the Chinese gross domestic product between 2001 and 2020, while only doubling energy use. Chinese companies producing batteries, electric vehicles, solar panels, and wind turbines are growing rapidly.

India says priority goes to economic growth to end poverty while shifting to cleaner sources led by solar energy. Our emissions per capita (i.e. per person) will never exceed those of rich nations, the government says.

Means to limit global warming

It is possible to reduce greenhouse gas emissions by making a transition to other energy sources in the future. The use of fossil fuels can be minimized. Low carbon technologies can be used and further developed. Energy savings, energy efficiency and combined use of energy from renewable sources are important means. Nuclear power is promoted as part of the solution. Technology to capture CO_2 from power plants and factories and store it in the underground is being developed. Preservation of forests and soils, and improvement of agriculture are also part of the solution. Geo-engineering may be the last resort.

Technologies that reduce the use of fossil fuels exist. Developed countries have the means to make the transition to low carbon economies, if they choose to do so. Developing countries have the opportunity to choose new development paths, although they may need support to do so. In climate change debate it is often called 'leapfrogging', meaning that you jump directly to more sustainable ways of doing things. An example is the way telephones have been introduced in many developing countries. Instead of using efforts and resources to draw cables, they jumped directly to the wireless technology of cellular phones.

Energy can be saved or used more efficiently in many ways
Some require nothing but good will. Others are demanding tasks. Some apply to wealthy countries, others to poor countries. Some changes can be made by individuals, while others require political decisions and investments in order to be made.

Examples: Stop cooking on an open fire, use a stove instead if you can afford it. Instead of heating leaky buildings, insulate. Build modern buildings that need almost no external energy for heating and cooling. Stop growing vegetables in heated greenhouses, when vegetables grown in open air are available. Stop using steel and aluminium when other materials can satisfy the needs. Stop driving fast in half empty vehicles. Stop flying so much. Stop buying things you really don't need. Buy energy-saving models. Be aware of your energy consumption. Change your habits. Consider going by bicycle. Turn off the light, when nobody is there.

Great efficiency gains are possible in power stations and in most industries. It is possible today to produce household appliances and electronics that perform much better than the old ones, while using less energy. In dense cities with efficient urban transportation, the energy need for transportation is much smaller than in sprawling urban areas with dense car traffic. On the other hand, modern cars can be made to use much less energy than heavy gas guzzlers. Washing machines can work with cold water, thanks to new enzymes in washing powders. Energy saving lightning bulbs are fairly widespread today. The next generation, LED-lighting, saves even more energy.

Typically, efficient devices cost more than the inefficient ones. However they often cost less, if you consider the total expenses during their lifetime.

Energy savings and energy efficiency pave the way to cover remaining energy needs by means of new, intelligently managed, energy systems, using **renewable sources**. The trick is to combine many sources and reach a maximum output with a minimum input. In many parts of the world, power stations are separated from heat stations. But combined heat and power production use much less resources. Wind-turbines and solar energy can be combined with backup sources such as hydropower and biomass for use when the wind does not blow and there is no sunlight. At night if the wind blows and nobody needs the electricity from the wind turbines, it can be used for loading batteries of electric cars and for heat pumps. Apart from wind power, solar heating and solar power, sources like tidal and wave power machines, geothermal energy, biogas and biofuels are being developed.

Most solutions are developed for relatively wealthy industrialised societies and cities. Developing countries, however, can leapfrog if a deal is made to support transfer of the best available technologies to them.

Nuclear power
Nuclear power is promoted as part of the solution. The advantage is abundant electricity with no emission of greenhouse gases. Disadvantages are that no final solution to radioactive waste problems has yet been found, uranium is not a renewable source, and fossil fuels are used to mine it. The total economy of nuclear power is a matter of much discussion. If it was decided to rely heavily on more nuclear power plants in the future, it will take several decades before they could cover substantially more of the worlds energy needs than they do today, the International Energy Agency says.

Carbon capture and storage (CCS)
CCS is proposed as a way to continue burning fossil fuels without harming the climate. The technique captures the carbon dioxide from the exhaust smoke, makes it clean and dry, puts it under high pressure to make it fluid, and pumps it back underground. The technology is not yet ready for use. It will take more than a decade before it is ready for large-scale use.

Preservation of forests and soils and improvement of agriculture
Preservation of forests and soils and improvement of agriculture can contribute much to limit greenhouse gas emissions. This may be facilitated by land reforms and changes in land use and agricultural methods.

Geo-engineering
Finally, so-called geo-engineering has been proposed as a way to save the planet from global warming if we do not manage to reduce greenhouse gas emissions quickly enough. One idea is to fertilise the ocean with iron to make algae grow fast and abundant and encourage them to absorb more CO_2 from the atmosphere. Another proposal is to shoot sulphur particles up into the upper atmosphere, where they would reflect some of the sunlight and cool the Earth. However none of these ideas have been proven and they could have dramatic and unexpected side effects.

How expensive is it to combat global warming?

The Intergovernmental Panel of Climate Change (IPCC) has reviewed cost analyses published in scientific papers. The panel concluded that the cost of stabilising greenhouse gas concentrations will not exceed 0.12 percent of world economic output per year. Some say that the costs of inaction exceed the costs of action. Others say that investments in other global problem areas would have better pay offs.

0.12 per cent is a fraction of expected economic growth. Whether this figure is considered to be high or low depends on how high future safety is valued, compared to present spending. It also depends on our expectations for the future and the risks we are willing to run.

Until recently, politicians and economists in many countries have said that cutting emissions would harm their economy. Today, on the contrary, many politicians and economists say that the shift to a low carbon economy would favour the economy of their country.

Sir Nicholas Stern
Advisor to the British government

The Stern Review recommends

Emissions trading
Emissions trading is a powerful way to promote cost-effective reductions. If targets are tight in rich countries, they would buy allowances worth tens of billions of dollars each year in developing countries, thus supporting their transition to low-carbon development.

Technology cooperation
Technology sooperation should be boosted. Support for research and development should double, and support for deployment should increase up to five-fold.

Forest protection
Curbing deforestation is a highly cost-effective way to reduce emissions. Today loss of natural forests contributes more to global emissions than the transport sector as a whole.

Adaptation
The poorest people and countries are the most vulnerable to climate change. Rich countries should honour their pledges to increase support and development assistance.

The world is expected to invest almost 1,000 billion US dollars each year from now through 2030 to provide energy for the growing world population, growing economies, and growing consumption. To halt global warming, even more money has to be invested, because low carbon technologies cost more money in the beginning, although they save money by using less fossil fuels in the long run.

Would it be wise if we did our utmost to stop burning fossil fuels and clearing forests as soon as possible? Or should we rather wait a little to see if the prices of new technologies will go down?

According to some economists, one should take into account that the actions to limit global warming will become easier to make in the future, because meanwhile technologies will become cheaper and people will become richer as a result of economic growth. It would be wiser to invest money in something more profitable or something with more immediate effect today – and to use money earned in the future to cope with global warming, they argue.

According to the Stern Review (a report on the economic consequences of climate change, made for the British Government, published in 2006), the costs of inaction 'far exceeds' the costs of reducing emissions. The costs of damages will grow as global warming accelerates. The costs of reducing emissions will pay back as new technologies become competitive, says the Stern Review.

The results of such economic calculations depend very much on the assumptions made about future growth and about the extent of future damages. If you expect high economic growth you will find future costs and required future investments to be lower than if you calculate future expenses at a lower rate of growth.

The different views on the economics of climate change also depend on ideologies and on different assumptions about how technology is developed. Some economists and politicians think that new technologies should be supported in the initial phase by means of legislation, finance and tough standards. In the end, they will be competitive, they argue. Others think that it should be left to the marketplace without public interference – except from research funding.

We are often told that global warming should be the defining task of our age – that we must cut emissions immediately and drastically. But people are not buying the idea that, unless we act, the planet is doomed.

Fortunately, there is a better option: to make low-carbon alternatives like solar and wind energy competitive with old carbon sources. This requires much more spending on research and development of low-carbon technology. We might have assumed that investment in this research would have increased when the Kyoto Protocol made fossil fuel use more expensive, but it has not.

Kyoto-style emissions cuts can only ever be an expensive distraction from the real business of weaning ourselves off fossil fuels. The fact is, carbon remains the only way for developing countries to work their way out of poverty. Coal burning provides half the world's electricity, and fully 80 percent of it in China and India, where laborers now enjoy a quality of life that their parents could barely imagine.

Bjorn Lomborg
Director, Copenhagen Consensus Center

New York Times, 25 April 2009

What are the costs and benefits?

The costs of greenhouse gas abatement vary significantly. Some energy savings and life style changes come for free. Some solutions have extra benefits such as less pollution and health improvement. Other solutions, notably the development and implementation of new technologies are costly, especially in the beginning. International cooperation can lower these costs and maximise the benefits.

Some solutions come for free
They are called no-regret solutions, meaning that the money saved is money earned. Co-generation of heat and power is cheaper than making power in one plant and water for heating purposes in another. It costs nothing to switch off the light when not used or to drive a low energy light-weight car instead of a heavy gas-guzzler. Insulation of houses pays back in a few years, depending on energy prices.

Some solutions have strong co-benefits
The time used in many African families to collect firewood could be used for better purposes if they had a stove. In many cities the exhaust from cars pollutes the air and kills many inhabitants or makes them ill. A shift to electric or hybrid vehicles will benefit the health as well as the climate. Sustainable management of forests and land is more profitable in the long run than forest clearing and land degradation.

Some solutions are cheapest when done in the first place
If more flooding is expected, it is cheaper to elevate cellars and roads in the first place than to do so after damages have happened. The same goes for most planning decisions.

Low carbon technology cost more money in the first place; later it becomes cheaper
Wind turbines are more expensive than conventional power plants – but once installed, they make electricity without fuel for many years. The same goes for most other renewable sources of energy and for energy efficient equipment. The problem is that many people and countries cannot afford such investments, because their money is needed for acute purposes.

Some of the low carbon technologies are expensive today
For instance, electric cars and solar power are definitely more expensive at present than similar diesel cars and electricity from plants fuelled by coal. Some people think that wealthy countries should support these technologies by buying them. Others argue that this money would be of more use if spent in other ways.

Some solutions will not be used if not financially supported
In many countries fossil fuels are subsidised in different ways. Some argue that such subsidies are “perverse” and should be immediately abandoned and the money be shifted to support for low carbon technologies. Many local politicians, however, are afraid that such a shift would cause their population to lose jobs and harm their economy.

4. The Economy of Technology and Adaptation

The price of using fossil fuels

To stimulate energy efficiency and spur the development of low carbon technologies the price of using fossil fuels can be raised by means of taxation or tradable emission allowances. If not compensated, high prices on fossil fuels harm the economy of developing countries. By contrast, developing countries might gain from emissions trading.

The prices of fossil fuels are determined by the world market. In recent years, the price, especially on oil, has fluctuated a lot, due to changes in demand as well as supply. It goes without saying that high and stable prices on fossil fuels favour the development and competitiveness of low-carbon technologies.

During a century or more, cheap oil, coal and natural gas have been the driving factors in the development of industrial societies. Many of these countries have put taxes on fossil fuels in order to finance public spending and because they wanted to stimulate energy savings, investments in energy efficiency and renewable energy sources.

High prices of fossil fuels are a burden especially to developing countries. In periods of high oil prices in the world market, governments in many developing countries have felt it necessary to subsidise fossil fuels in order to keep their economies running and ease the living of their populations.

Uniform taxes on fossil fuels are favoured by some economists and environmentalists as an efficient tool to spur the transitions towards low carbon economies. Poor people and poor countries could be compensated in other ways for the opportunities lost. For instance, the revenues from taxation could be used to support poverty alleviation, sustainable development and access to low carbon energy services.

Fuel taxes are fairly simple to control, and the resulting higher price on electricity and gasoline would send a clear signal to car and home owners, trade, and industry. However, the idea of global carbon taxes is complicated because most countries insist that taxation is a strictly national matter.

One step in that direction could be taxation of fuels for ship and air transport, since these fuels are not currently taxed by any nation and because the emissions from international transport by air and by ship are growing. It would be easy, however, for airlines and shipping companies to avoid such a tax if just a few countries would allow tax-free fuel sales.

Carbon trade may be less efficient, but it has the advantage of being more widely accepted. Carbon trade among nations is part of the Kyoto Protocol. The European Union has a carbon trading scheme for companies as well. The United States is in the process of making a similar trading scheme. It is expected that international carbon trade will be an important part of a new climate deal.

If strictly and consistently carried out, carbon trade will work as an incentive to reduce the use of fossil fuels and deforestation. However, if too many allowances are distributed and if general economic activity diminishes, the system does not work, because the price of buying an allowance to emit 1 ton of greenhouse gas falls. Companies in need of allowances can then buy them cheaper than the cost of investment in low carbon, climate friendly equipment or energy savings. This has happened twice in Europe. To prevent it from happening again, the European Union has decided to auction the allowances instead of distributing them freely.

From the point of view of many developing countries, carbon trade has the advantage that it can attract investments from countries and companies in need of emission allowances.

Adaptation needs

Some countries have started to adapt to the unavoidable part of future climate change. The most vulnerable countries and people are in need of support to do so.

All countries will have to adapt to climate change, since the global warming due to past emissions will cause a global warming of more than 1 degree above pre-industrial levels. On a limited basis, some countries have begun to adapt. Examples are coastal defence in the Maldives and the Netherlands, prevention of glacial lake outburst in Nepal, water management in Australia, and government responses to heat waves in some European countries.

Many early impacts of climate change can be successfully addressed through adaptation. With further climate change the options to adapt will diminish and the costs will increase. A wide array

of possible responses to climate change exists. It encompasses change of policies, management, behaviour, constructions and other technical changes. Examples span from new planning regulations to building of dikes and change of land use.

Adaptation requires many barriers to be overcome: lack of information, lack of money, resistance against proposed changes, etc. The lack of capacity and resources are crucial, particularly in developing countries.

Other stresses such as poverty, unequal access to resources, food insecurity, conflicts and diseases can exacerbate the vulnerability to climate change. Sustainable development can reduce these threats. In all circumstances, many negative impacts of climate change can be avoided if societies are well prepared.

Need of technology transfer

It is in the interest of all people that developing countries reduce their emissions. To do so they need new technologies. Support and cooperation is required to enable smooth transfer of technologies.

It is in the interest of all world citizens that developing countries do not follow the same development path and repeat the mistakes industrialised countries made before anyone knew about global warming.

Today, however, coal is still a cheap source of energy and old-fashioned devices are cheaper than modern low-energy and low-carbon technologies. The new technologies are developed mostly in high-income countries.

To limit or reduce emissions in developing countries, transfer of these technologies is required. Property rights to these technologies are often owned by companies, which want to profit from them to recover their investments in research and development.

To accelerate the transfer of technology, a new climate deal has to make arrangements to support it economically.

There are two issues here. One is to compensate partly for the price difference between old and new technologies. The other is that climate friendly energy technologies in general have high initial costs followed by lower costs of fuel consumption. Therefore wider investment flows and access to finance of high upfront investments are necessary.

One proposal is that countries who limit their emissions substantially compared to baseline will be entitled to have the acquirement of new technologies supported accordingly.

Funding of adaptation and technology transfer

In current negotiations to reach a new deal, funding of adaptation and technology transfer plays a major role for two reasons. One is that many vulnerable countries are in dire need of means to prevent the impacts of climate change. Another reason is that developing countries find it just and fair that rich countries with ample resources and high emissions pay to repair the damage they are mostly responsible for.

Many countries– and among them many poor countries – are in dire need of capacity and equipment to adapt to climate change. They also lack the technology to curb the rise in their emissions. Those who have not had much emission of greenhouse gases during their history feel

that developed countries which have built much of their wealth on the use of fossil fuels, should take responsibility for providing the necessary funding.

Without adequate funding of adaptation and technology transfer, no climate deal will be regarded as fair and just by the majority of parties. Estimates of the amount needed are generally well above 100 billion US dollars a year.

It is expected that funding will have to come from many different sources. These include government assistance and loans, World Bank Climate Investment Funds, UN governed funds, private sector funds, perhaps supported by government incentives, etc.

It is debated whether some kind of financial system should be installed, which would automatically generate the funding needed, rather than depending on commitments made by individual countries through negotiations. Such a system could be installed by putting a levy on carbon trade; by putting tax on fossil fuel emissions and international transport; by making developed nations pay a fixed part of their national income; or by putting a tax on international, monetary transactions.

It is also debated which countries should be obliged to contribute to the funding needed. Many developing countries feel strongly that funding should be an obligation only to developed nations, with the exeption of the least developed countries. Others argue that some developing countries should also be obliged to contribute, but taking issues such as emissions, population size and economic development into account.

Least developed countries

According to the UN, the least developed countries are:

Afghanistan, Angola, Bangladesh, Benin, Bhutan, Burkina Faso, Burundi, Cambodia, Cap Verde, the Central African Republic, Chad, Comoros, the Democratic Republic of Congo, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Haiti, Kiribati, Laos, Lesotho, Liberia, Madagascar, Malawi, the Maldives, Mali, Mauritania, Mozambique, Myanmar, Nepal, Niger, Rwanda, Samoa, Sao Tomé and Principe, Senegal, Sierra Leone, the Solomon Islands, Somalia, Sudan, East Timor, Togo, Tuvalu, Uganda, Tanzania, Vanuatu, Yemen, and Zambia.

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This paper largely builds on The Intergovernmental Panel of Climate Change, IPCCs Fourth Assessment Report, *Climate Change 2007*. The information, however, is condensed and simplified. IPCC reports are not easy to read. But you can easily find them at www.ipcc.ch. The sections on Frequently Asked Questions are useful to readers with no scientific education.

References are made, when possible, to the Summaries for Policy Makers (SPMs) which are approved by scientists and government representatives as well.

The assessment consists of three main reports: Working Group I on The Physical Science Basis, Working Group II on Impacts, Adaptation and Vulnerability and Working Group III on Mitigation of Climate Change. They are summarised in the Synthesis Report.

Since the report was published: More than 2,000 scientists attended the Copenhagen Climate Congress March 2008. The Congress delivered six key messages. Link: http://climatecongress.ku.dk/.

By June 2009, when this paper was finished, the negotiation text was FCCC/AWGLCA/2009/8 of May 19, 2009. Link: http://unfccc.int/documentation/documents/items/3595.php#beg. Subsequent negotiation texts can be found at www.unfccc.int.

Foreword

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Urgency

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Deniers and sceptics: A prominent denier is the president of the Czech Republic, Vaclav Klaus. »Global warming is a false myth and every serious person and scientist says so«, he said in a speech at the Cato Institute, Washington March 9, 2007. The director of Urban Renaissance Institute, Lawrence Salomon, wrote the book The Deniers: *The World Renowned Scientists Who Stood Up Against Global Warming Hysteria, Political Persecution, and Fraud** And those who are too fearful to do so*, 2008. Among the deniers and sceptics mentioned are Edward Wegman, George Mason University, Richard Tol, University of Hamburg, Duncan Wingham, University College, London, Richard Lindzen, Massachusetts Institute of Technology, Henrik Svensmark, Danish National Space Center, and Nir Shaviv, Hebrew University, Jerusalem.

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