CLEAR FACTS ABOUT CLIMATE CHANGE
To look into the issue of climate change, the UN set up the Intergovernmental Panel on Climate Change, IPCC, in 1988. The IPCC consists of several hundred scientists from various disciplines the world over and its main task is to analyse and evaluate climate system research on a regular basis. Its tasks also include describing the effects of climate change as well as shedding light on possible adjustments to be made and measures to be taken. The analyses are intended to form an impartial basis for decision-making.

In its third evaluation report 2001, the scientists give an update on the current level of knowledge regarding the earth’s climate system and how it is being affected by human activities. The report also describes the vulnerability of different sectors of society faced with a warmer climate, how eco-systems are affected as well as the impact on human health. Various measures for limiting climate change are also discussed, such as reducing emissions and making use of forests and land areas as carbon sinks. Despite prevailing uncertainty, the climate panel’s message is clear; there is no longer any doubt that we really do contribute to global warming.

The evaluation was presented in October 2001 and is adjudged to have been an important basis for the international negotiations taking place within the framework of the UN Convention on Climate Change. In the autumn of 2001, a decision was taken in Marrakech to adopt common regulations on emission reductions under the so-called Kyoto Protocol.

This publication is a summary of the IPCC’s third evaluation report. The text has been scrutinised by expert climatologists and metrologists in Sweden.
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A WARMER WORLD

There is now greater consensus than ever on the fact that humans really do affect the climate. According to the IPCC, the increase in the earth’s average temperature observed over the last 50 years can only be explained if anthropogenic emissions of greenhouse gases are included in the equation.

Emissions of greenhouse gases recognise no borders. Our use of fossil fuels in industry and for transport, in electricity production and for heating causes emissions that bolster global warming. Global warming which in turn leads to changes in the earth’s climate. Global warming which within the not-too-distant future may bring increasingly more frequent and heavier rainstorms to northern Europe and which is already threatening dry regions with exacerbated drought and the increased spread of disease.

It is thought that a change in the earth’s climate may have positive effects on certain regions such as larger harvests within agriculture and forestry. But the positive effects are on the wane and are being replaced by negative ones, the more dramatic climate change becomes and the faster it happens.

A future temperature increase appears unavoidable. But we can still exert our own influence on how much and how quickly it will rise. The good news in the IPCC’s third report is that the increase in the earth’s average temperature can be limited to 1.5 degrees Celsius during the 21st century – provided measures are implemented.

Greenhouse gas emissions can be reduced considerably with the help of a whole host of energy-efficient technologies and management methods which exist today for energy supply and consumption as well as in the fields of agriculture and forestry. A large proportion of these technologies and methods can also be implemented at a relatively small expense or at no cost at all for society. Such a development, however, presupposes guidelines and decisions that will eradicate existing obstacles before this technology can manifest itself on the market. It also requires more research and the transfer of technology and knowledge to developing countries.

Climatologists warn against the postponement of measures to combat climate change. The journey towards a warmer world has already begun. Several of the changes in temperature and to our natural environment that have recently occurred can be put down to anthropogenic climate change. The extent of snow coverage and ice-caps in the Arctic is diminishing, temperatures on land and in the sea have increased during the 20th century while sea levels have risen by 10-20 centimetres.

Adapting to a changed climate is now a necessary strategy on all levels of society and should, according to the IPCC, be supplemented by efforts to take care of the causes of climate change. We can ourselves influence the future climate. The way society chooses to develop will govern the opportunities we have to limit the effects of our own influence on the earth’s climate.
Anthropogenic climate change must not be viewed solely as an environmental problem. It is rather a question of the actual prerequisites for long-term sustainable development. Quite simply, it jeopardises our chances of being able to satisfy our basic needs such as sufficient food, clean water, a healthy natural environment, and our ability to make a living and have a safe place to live in most parts of the world.

At present, we do not know exactly what climate change involves. And there is nothing to suggest that we will be any more certain in the immediate future. But the risks remain; climate change can have major, negative consequences for agriculture, our social structure, economy and ecosystems. The precautionary principle applies; measures to limit climate change are a process that must be driven forward despite the lack of unequivocal scientific evidence.

The IPCC chairman, Robert T Watson, presents the future challenges for the world’s decision-makers in three parts:

**The risk constituted by anthropogenic impact on the climate system must be dealt with, despite the continued existence of scientific uncertainty.**

Decision-makers should realise that scientific uncertainty works on both sides; scientists can both underestimate and overestimate our impact on the earth’s climate. They must also realise that climate-related changes in the natural environment and social systems are neither quickly nor easily reversible.

The decisions taken over the next few years will set limits for what measures can be chosen in the future, since rapid increases in emissions in the immediate future will necessitate even more dramatic reductions if we are to reach the targets set for concentrations of greenhouse gases in the atmosphere.

Delaying the implementation of measures may reduce the costs of limiting climate change at present since it allows us to bide out time as regards technological development. But delaying action may also lead to greater and more rapid climate change and hence higher costs for adaptation and damage.

**Preventive measures for limiting the effects of anthropogenic climate change must be considered.**

Decision-makers must commit themselves as regards measures to reduce emissions as well as those that will facilitate adjustment so as to strengthen the capacity of vulnerable ecosystems to recover.

Delaying measures risks leaving countries and the international community poorly prepared for serious climatic disturbances. Insufficient measures, or none at all, will also increase the risk of irreversible and extremely expensive climate change effects. Measures that can currently be justified for other reasons and that also allow society to be more flexible in the face of climate change can be considered first of all.

**Without measures to reduce greenhouse gas emissions, global warming will occur at a previously unsurpassed rate.**

Without measures to reduce rising greenhouse gas emissions, the assessment is that global warming will occur at a previously unsurpassed rate. The consequences for society may well be extremely serious and completely undermine the prerequisites for long-term sustainable development.
In its third evaluation report, the IPCC concludes that:

1. **The earth’s climate has changed since the beginning of the 20th century. Some of these changes can be put down to human impact alone.**
   - The average temperature of the earth has increased by 0.6 °C (± 0.2 °C) since 1860. The last two decades were the warmest of the 20th century.
   - The temperature increase that has occurred in the northern hemisphere over the last 100 years (20th century) is probably greater than for any other 100-year period over the last 1,000 years.
   - Precipitation patterns have changed. For example, the incidence of heavy rainfall has increased in some regions.
   - Sea levels have risen 10-20 centimetres since the beginning of the 20th century. Most glaciers outside the polar regions have receded. The ice-cover of Greenland and the rest of the Arctic has gradually diminished since 1950.
   - Most of the global warming that has occurred over the last 50 years originates from human activity.

2. **Carbon dioxide concentrations in the atmosphere, the earth’s average temperature, precipitation and sea levels are all expected to rise during the 21st century as the result of human impact.**
   - All the IPCC’s future scenarios of social development show that carbon dioxide levels in the atmosphere are set to rise considerably during the 21st century. Depending on the measures implemented, CO₂ levels in the atmosphere will probably be between 50 and 160 per cent higher towards the end of the century compared to today.
   - Climate models indicate that the earth’s average temperature will have risen by 1.4 to 5.8 °C between 1990 and 2100. This spread is mostly due to the different assumptions as regards social development rather than the degree of uncertainty in the climate models. Temperatures are estimated to rise more over land than at sea.
   - Average precipitation is expected to rise but locally precipitation amounts may both increase and decrease. The incidence of heavy rainfall is expected to increase in many land areas.
• Sea levels are expected to have risen by between 9 and 88 centimetres between 1990 and 2100. The spread here is mainly due to different assumptions as regards social development.

• The number of extreme weather phenomena such as heat waves, heavy rainstorms, flooding, droughts and fires is expected to rise.

3. Biological systems have already been affected, especially by regionally occurring temperature increases.

• Growing seasons in the northern hemisphere have lengthened by between one and four days per decade over the last 40 years.

• The migration patterns of birds have changed and they now lay their eggs earlier in the year.

• Distribution limits for plants, insects and animals have shifted towards the poles and up onto higher altitudes.

4. Anticipated climate change will have both positive and negative effects on water resources, agriculture, natural ecosystems and human health. The greater the climate change, the more dominant negative effects will be.

• Society’s vulnerability faced with climate change will be determined by its extent and at what rate it occurs. This applies to agriculture, forestry, fisheries, water resources, our social structure, terrestrial and marine ecosystems as well as human health.

1. Anticipated temperature increases during the 21st century compared with temperature changes over the last 1,000 years

The anticipated increase in temperature during the 21st century is without parallel during the last 1,000 years of planet Earth’s history. Temperature data from the year 1000 to 1861 is for the northern hemisphere and is from studies of annual tree rings, corals, bore-cores of ice and historical data. The temperatures given for 1861 to 2000 are recorded ones. The temperatures given for 2000 to 2100 show the outcome of the IPCC’s various scenarios for temperature increase, see page 17.
Climate change can have positive effects in some regions and within some sectors. A slight increase in temperature is expected to lead to an increase in agricultural production in areas at medium-high and high latitudes. The IPCC points out, however, that most of the effects of the anticipated climate change are negative. The effects of an increased incidence of extreme weather phenomena such as heavy rainstorms, tidal waves and cyclones are particularly serious.

- Tens of millions of people will be exposed to a dramatically increased risk of flooding as a result of heavy precipitation and higher sea levels.
- Water supply may diminish in many regions where there is already a lack of water, especially in peripheral tropical regions. For example, the whole of the Mediterranean area is expected to become much drier.
- Agricultural production drops every time there is a temperature increase in most central and peripheral tropical regions.
- Mortality caused by heat is expected to rise. Considerably more people will be exposed to diseases such as malaria, dengue fever and cholera.
- Some natural ecosystems may be subject to considerable and irreversible damage. These include glaciers, coral reefs and atolls, mangrove forests as well as ecosystems in polar and alpine regions.
- The risk of extinction of some extra-sensitive species and biodiversity losses is increasing.
- The adjustment to a hotter climate with new conditions for a number of sectors is a necessary strategy and should supplement measures implemented to combat climate change.
- Developing countries and their poor populations are most vulnerable as they lack the financial, technical and institutional resources in order to adapt to the effects of climate change.

5. Both technical solutions to reduce greenhouse gas emissions and the opportunity to keep down the cost of measures exist. But obstacles to the development and use of climate-friendly technology must be surmounted.

- Stabilising greenhouse gas concentrations in the atmosphere will require emission capping in all regions.
- Reducing greenhouse gas emissions requires new energy extraction methods, new transport fuels and new engine combustion techniques. In addition, efforts to render energy use more efficient are needed.
- Considerable technological progress has been made over the last five years, and faster than expected. Examples include the development of wind turbines, hybrid vehicles, fuel cell technology and techniques for the underground storage of carbon dioxide.

Powerful computers simulate the climate

Powerful, advanced computers help scientists to understand how the climate system works. The complicated connection between the atmosphere, the land and ecosystems is described in computer models. Here, ocean currents and the behaviour of the wind can be explained and changes in how icecaps melt can be studied. Computer models can also explain how and where steam and clouds are formed, where and when rain and snow fall and how the snow coverage of the different continents varies depending on the time of year.

Computer simulations can also indicate how the climate may change when the amount of greenhouse gases in the atmosphere increases. When assessing the future climate, the models take a number of other factors besides greenhouse gases into account. These include the occurrence of aerosols (sulphur particles) in the atmosphere, ozone-layer depletion in the stratosphere and the interaction with natural phenomena such as volcanic activity and solar radiation variations.
- There are measures that can be implemented at a net profit. The fact that this is possible depends on:
  - in some cases, a poorly functioning market,
  - the adding of concurrent profits within other areas, e.g. improvements in regional and local air quality and,
  - the scope for improvements in public health.
- Forest and farmland along with other terrestrial ecosystems have considerable potential for storing carbon dioxide. Globally speaking, these can store up to 200 gigatonnes of carbon over the next fifty years. This corresponds to about half the carbon dioxide emissions the world is expected to generate up until 2050.
- The costs of stabilising carbon dioxide levels in the atmosphere increase somewhat if they are stabilised at 550 ppm rather than 750 ppm. The increase in costs for stabilising the levels at 450 ppm is, however, greater, mainly as a result of the premature liquidation of investments already made.
- The costs of implementing international requirements on emission reductions vary from one region to the next depending on how the so-called Kyoto mechanisms are utilised and the way they fit in with the measures taken within each country respectively.
The IPCC’s third report is a comprehensive evaluation of the research into climate change. Previous presentations of the knowledge level (1990 and 1995) have been supplemented in several areas and the IPCC is now expressing itself much more clearly than previously about the role of humans in the global warming that has been observed.

Considering both natural variations in the climate and changes in solar radiation, scientists have established that anthropogenic emissions of greenhouse gases have clearly contributed to the 0.6º Celsius rise in the earth’s average temperature during the 20th century.

The IPCC’s latest assessment of the future climate and emissions is based on new scenarios where the effects of measures have been given a more significant role than previously.

The IPCC now anticipates, for example, a more substantial reduction in the occurrence of aerosols towards the end of the 21st century, compared to previous calculations. This in turn is the reason why scientists believe the temperature increase may be greater than has been previously assumed. According to the IPCC, the earth’s temperature is expected to rise by between 1.4 and 5.8º Celsius during the 21st century.
A changing climate

Studies of bore-cores from the Antarctic ice-masses show that the earth’s climate has been relatively stable over the last 10,000 years. In no single century during this period has the change in the global average temperature been greater than one degree.

Registrations of the average temperature on the earth’s surface do show, however, that the climate is now getting warmer at the same time as precipitation patterns are changing. The average temperature has increased by 0.6° Celsius (±0.2) during the 20th century and temperatures in land areas have risen more than those in the oceans. The 1980s and 1990s were the warmest decades of the century and the twelve warmest years in the last hundred have all occurred after 1983. The temperature at the earth’s surface has increased more during the last century than at any time over the last 1,000 years.

In addition, measurements show that the sea level is rising and that glaciers are getting smaller in size all over the world. The ice-cover of the Arctic has decreased and the ice gets thinner during the summer than it used to.

In a global perspective, a greater proportion of all precipitation falls in the form of violent storms. Extreme weather phenomena are becoming increasingly more common in some parts of the world. The extent, frequency and strength of the El-Niño weather phenomenon has increased since the middle of the 1970s resulting in serious flooding and dry periods in the Tropics and their periphery.

2. The relative mean value of the earth’s temperature for the period 1961-1990

The last 100 years (20th century) have been the warmest 100-year period in a thousand years. The figure shows temperature deviations, the continuous curve shows the temperature evened out over ten years.
Human activities have changed the composition of the atmosphere. Since 1750, concentrations of the greenhouse gases carbon dioxide, methane and nitrogen oxide have risen dramatically.

Aerosols are small airborne particles in the atmosphere. They can emanate from natural sources such as sandstorms, fires and volcano eruptions. They can also be of anthropogenic origin, i.e. the burning of everything from harvest residue to fossil fuels, and they often consist of sulphur or carbon particles.

Aerosols from volcano eruptions can be dispersed all around the world and may remain in the atmosphere for several years. Aerosols from small-scale, local emissions often disappear within the course of a few days or weeks.

The occurrence of these particles is greatest over industrialised regions. When measures are taken to control emissions, their concentrations in the atmosphere drop rapidly.

Reductions in sulphur emissions are of considerable significance for future assessments of temperature changes since such emissions lead to the formation of so-called aerosols in the atmosphere. Aerosols have a cooling effect and hence the opposite effect to warming at the earth’s surface.
Levels of greenhouse gases in the atmosphere are increasing

The concentration of greenhouse gases in the atmosphere has risen as a result of human activities. This rise is primarily due to the burning of fossil fuels (coal, oil and gas), but deforestation and the cultivation methods employed by agriculture have also played a part.

Since before the industrial revolution (1750), carbon dioxide concentrations in the atmosphere have gone up by 30 per cent. Methane gas levels have doubled whilst nitrous oxide concentrations have increased by 15 per cent. Levels of these greenhouse gases are now higher in the atmosphere than they have been at any time over the last 420,000 years.

In parallel with global warming, concentrations of so-called aerosols have increased in the atmosphere, primarily over the northern hemisphere. Sulphur emissions from coal burning are the main cause. Whilst greenhouse gases have a tendency to make the atmosphere warmer, aerosols have a cooling effect. Sulphur emissions have, however, decreased in recent years.

Humans contribute

According to the IPCC, most of the global warming observed over the last 50 years is due to humans emitting large quantities of greenhouse gases to the atmosphere since the birth of industrialism.

Results of computer simulations show that the increase in the earth's average temperature can only be explained if anthropogenic emissions of greenhouse gases are included in the equation. Natural impact on the climate system such as changes in solar radiation and volcanic activity cannot explain the temperature increase recorded since 1950.

Conversely, however, anthropogenic emissions of greenhouse gases and the impact of aerosols on the climate system cannot be solely responsible for the change in the earth's average temperature. The results indicate rather that humans have intensified an ongoing, natural warming of the climate.

Global warming – natural but intensified

The earth’s climate system is controlled by many different factors. The most important of these is the sun’s radiation, which heats the earth, as well as the planet’s capacity for retaining and redistributing heat over different areas. The natural greenhouse gases in the atmosphere capture the radiation that is reflected from the earth’s surface and transmit some of it back towards Earth.

By utilising natural resources, mankind is now increasing the greenhouse gas concentrations in the atmosphere. More heat is retained at the earth’s surface resulting in rising temperatures. Global warming is being intensified.

The burning of fossil fuels (coal, oil and gas) releases carbon dioxide and constitutes the largest source of greenhouse gas emissions from human activities. These emissions emanate for example from heating, transport and industrial manufacture.

Deforestation contributes to an increase in carbon dioxide in the atmosphere since forest that is cut down can no longer assimilate the carbon dioxide. Nitrous oxide (laughing gas) and methane are released from agriculture. These are also powerful gases that intensify global warming when their concentrations in the atmosphere rise.

Vapour: When the temperature rises, the air can contain more vapour. Aqueous vapour is a powerful greenhouse gas and large quantities of it in the air will therefore intensify warming.

Clouds: Clouds cool the earth by reflecting solar radiation back into space. But clouds can also function as a blanket that is warming the earth’s surface. It is currently considered that the cooling and warming effect of clouds basically cancel each other.

Ice and snow: White ice and snow reflect sunlight and keep the earth cool. But when the climate gets warmer, thawing accelerates. Land and water are exposed and the darker areas absorb solar radiation. Warming is intensified.

Long-term and large-scale disturbances in the climate system will probably work together with natural climatic variations. Over different time periods, this can both aggravate and alleviate the effects of climate change.
Results of computer simulations show that the increase in the earth’s average temperature can only be explained if anthropogenic emissions of greenhouse gases are included in the equation. Natural impact on the climate system such as changes in solar radiation and volcanic activity cannot explain the temperature increase recorded since 1950 (a).

Simulations of human impact provide a reasonable explanation for the rise in temperature (b), but the model results concur best with recorded average temperatures when both human impact and natural climatic factors are included in the equation (c).
The temperature is increasing and the sea level is rising

Between 1990 and 2100, the average temperature at the earth’s surface is expected to rise by between 1.4 and 5.8ºC. This span is greater than the IPCC previously stated, due, for example, to a lower estimate for sulphur dioxide emissions and hence a reduced occurrence of cooling aerosols in the atmosphere.

In many ways, the anticipated temperature increase is unique. Not only is it two to ten times higher than the average change over the last 100 years (0.6ºC), but it is also unique compared to temperature changes over the last 1,000 years.

In addition, the specified temperature increase is occurring considerably more quickly than the changes in average temperature that have happened over the last 10,000 years.

As a result of the increase in temperature, the sea level is expected to rise by between 9 and 88 centimetres by 2100. The principal reason is the larger volume of warmer water and increased (discharge from) melting glaciers.

Since sea water is being warmed up slowly, the rise in sea level is somewhat delayed in relation to global warming. This means that sea levels will continue to rise for a long time after the climate has been stabilised.

5. Increased levels of greenhouse gases in the atmosphere cause temperatures and sea levels to rise

Average temperatures are expected to increase and the sea level will rise as a result of higher concentrations of greenhouse gases in the atmosphere. The colour span in each figure respectively indicates the uncertainty for each scenario.
Dry areas may become drier

The climate models ascertain that evaporation from the earth’s surface increases as the climate gets warmer. As a result of decreased precipitation and increased evaporation, many areas that are already dry will be expected to become even drier. This pertains primarily to the peripheral regions of the Tropics. Average precipitation is estimated to decrease generally in the Sub-tropics in a broad belt around 25 N (though not over East Asia) and 25 S.

Precipitation patterns will change and rainy periods may occur at other times of the year than they do now. Even areas that receive more precipitation may be conversely affected by reduced surface runoff and decreased humidity in the soil as a result of increased evaporation.

Average precipitation is expected to rise in general in tropical regions around the Equator, especially over tropical sea areas and over land in parts of northern Africa and southern Asia. Increases are also expected at medium–high and high latitudes from 45 N to the North Pole and from 45 S to the South Pole. This includes northern Europe and Scandinavia as well as corresponding regions in the southern hemisphere.

Future emissions

The IPCC emphasises the fact that future emissions of greenhouse gases, and likewise the occurrence of aerosols in the atmosphere, will be determined by how society develops. Emissions are affected by economic growth, the extent of development and to what degree new technology is made available on the market. They are also influenced by population growth and of the emergence of a regulatory framework to control and govern emissions worldwide.

All the IPCC’s scenarios for future emissions show that concentrations of mainly carbon dioxide in the atmosphere are set to rise considerably during the 21st century. For example, carbon dioxide emissions from the burning of fossil fuels and deforestation in tropical regions are expected to result in between 5 and 35 gigatonnes of carbon a year in 2100, compared to average emissions during the 20th century of approximately 7.5 gigatonnes of carbon per year.

These emissions would mean a rise in carbon dioxide levels in the atmosphere from their current level of about 370 ppm to between 540 and 970 ppm in 2100. If uncertainty in the form of changes in the significance of carbon sinks and their size are included in the calculation, concentrations of carbon dioxide in the atmosphere are instead expected to be between 490 and 1,260 ppm in 2100.
The scenarios of how greenhouse gas emissions and aerosol-forming substances, especially sulphur, will develop in the course of time have been an important starting-point in the work of the IPCC. Feasible developments regarding greenhouse gas and sulphur emissions are described in special emission scenarios. The scenarios differ depending on the assumptions made about development, for example regarding economic and population growth.

There are four main scenarios, one of which has been divided into three different technical developments (A1FI, A1T, A1B). The world’s population rises in all the scenarios while GDP rises and income differences even out. The assumptions vary, however, as to how energy systems and land use will develop. In some scenarios, carbon dioxide emissions will have decreased by 2100 compared to 1990 levels. In others they have increased six-fold.

The various scenarios are all deemed feasible but none is seen as more probable than the others. No assumptions on emission controls (e.g. the Kyoto Protocol) have been included.

**A1**  Only slight population growth, rapid economic growth, introduction of new technology and renewable fuels. Global solutions are sought after. How alternative developments concerning fuel affect matters is shown in three sub-scenarios:
- A1FI  Major coal and oil use.
- A1T  Major use of non-fossil, renewable fuels such as biofuels, solar and wind power (these would cover 85 per cent of energy production in 2100).
- A1B  Renewable fuels used to the same extent as coal and oil.

**A2**  Major population growth, slow economic growth and weak technological development. A heterogeneous world with major variations in regional development.

**B1**  Slight population growth (equal to A1). A comprehensive change in global economic trends towards more services, IT and more efficient resource use. Global solutions and sustainable development are the aim. Disparities in the world are being reduced.

**B2**  Fairly large population growth. Development aiming towards sustainability but with considerable numbers of local solutions instead of global ones.

**IS92a**  Average population growth leading to moderate development in emissions.

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**Carbon dioxide emissions**

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**Carbon dioxide concentration**

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**Sulphur dioxide emissions**

<table>
<thead>
<tr>
<th>IPCC scenarios</th>
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<th>A1T</th>
<th>A1FI</th>
<th>A2</th>
<th>B1</th>
<th>B2</th>
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</tbody>
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ppm = parts per million, volume units and measurements of greenhouse gas concentrations in the atmosphere.
**The ice is melting**

Snow cover and icecaps in the northern hemisphere are becoming smaller in size and are expected to decrease further in the future. Most glaciers outside the polar regions have receded. The ice-masses in the Arctic has gradually diminished since 1950.

The ices of the Antarctic will probably grow over the next hundred years as a result of increased precipitation. Further global warming may, however, cause the Antarctic ice-cover to diminish considerably in size. The ice-melt may raise the sea level by several metres over the next 10,000 years.

In contrast to the ice masses of Antarctica, the Greenland ice-cap will be reduced in size over the next hundred years. This will raise the sea level by a few centimetres. Climate models indicate that a local warming of more than three degrees would lead to the complete melting of the Greenland icecap if it continued for for thousands of years.

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**El Niño more and more common?**

This climate phenomenon is a periodic warming of the surface water in the eastern parts of the Pacific Ocean - a regional phenomenon that affects the climate in large parts of the world.

El Niño normally leads to cloud systems being displaced eastwards, which in turn causes drought in Indonesia and Australia. The Central Pacific is hit by heavy rainfall and hurricanes, which are normally rare in that part of the world. Even Ecuador and Peru, which normally have a desert-like climate, receive heavy rainfall causing flooding and erosion of the otherwise dry landscape. El Niño returns as a rule every fourth to seventh year and lasts for about 12 to 17 months.

Not only has El Niño become more common since the 1970s but it lasts longer and is more powerful. Climate models indicate a future strengthening of El Niño, something that will bring with it both more dry periods and flooding in tropical regions. There is, however, considerable uncertainty surrounding the weather phenomenon’s future behaviour.

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**7. Occurrence and extent of the El Niño weather phenomenon 1870-1999**

The El Niño weather phenomenon has become more common and more powerful since 1970. The figure shows the changes in the relative average value of the surface water temperature for the period 1961-1990.

The La Niña weather phenomenon has likewise become more intense during the period. La Niña is associated with cooler water than normal. The phenomenon occurs in the Pacific Ocean around the Equator.

*Source: Raynor et al. 2000, Kaplan et al. 1998, Smith et al. 1998*
The question is not if the climate will change as a result of human activities, but rather by how much will it change, where and when. According to the IPCC, we are facing inevitable climate change and we can only influence how fast it happens and to what extent. Climate change will seriously affect both the natural environment and economic and social values in many parts of the world. These include water resources, agriculture, forestry, fisheries, entire ecosystems and many human communities.

Our own health is under threat from, for example, reduced access to food and water and from increased exposure to insect-transmitted diseases. The IPCC draws the conclusion that most people will be negatively affected by climate change.
The rate of change is important
The vulnerability of water resources, agriculture and forestry, fisheries and our communities faced with climate change will be determined by the extent of the change and the pace at which it occurs. If temperatures rise quickly, there is less chance that ecosystems will be able to adapt to the new climatic conditions. Changes in the incidence of extreme weather phenomena will have a major bearing on the degree of vulnerability.

The IPCC points to the fact that an anthropogenic climate change is a new stress factor for many ecosystems. Ecosystems that in many cases are already exposed to negative impact from such things as pollution, increasing natural resource extraction and unsustainable cultivation methods.

Developing countries more vulnerable than their industrialised counterparts
The possibility to adapt within areas such as water supply and agriculture increase in line with technological advancement and as new cultivation methods are developed. But seldom do developing countries have either access to modern technology, the financial resources to adapt or the appropriate information about their opportunities to do so. The IPCC ascertains that vulnerability increases when the opportunities to adapt are few.

The efficiency and cost-effectiveness of the measures taken will be dependent on cultural, educational, institutional and legal conditions and approaches. If the effects of climate change are included in the calculations, when resource and development issues are being discussed and when investments in infrastructure are being planned, adaptation to the climatic conditions in a warmer world will be made easier.

Increased risk of water scarcity
Despite an increased amount of total precipitation over the earth, the amount of rain over most of the world’s dry areas will diminish. It is expected, therefore, that climate change will aggravate the water scarcity problem in many regions that are already dry. An estimated 1.3 billion people currently do not have access to sufficient quantities of clean water. The IPCC has established that developing countries are very vulnerable to climate change since many of them are situated in dry regions.

Water quality will be negatively affected by a rise in the water temperature and by pollution from flooded rivers. When the sea-level rises, saltwater can penetrate wells and drinking water reservoirs near the coast.

Agricultural productivity will change
A slight increase in temperature is expected to lead to an increase in agricultural production in areas at medium-high and high latitudes. Agricultural production is, however, expected to fall at medium-high latitudes if the temperature rises by more than 2 to 3 degrees.

In parts of the Tropics and their periphery, a rising temperature will lead to reduced production. There are already many crops in this region that are close to the limit for what they can tolerate with regard to temperature. The region is characterised by dry, poorly irrigated agriculture and harvests will probably diminish with every slight increase in temperature. In Africa and Latin America, agricultural production is expected to fall by 30 per cent during the 21st century. The risk of starvation in some densely populated regions is expected to rise.

It is the IPCC’s estimation that agricultural production — globally — can be maintained at its present level provided that the temperature increase is not greater than just a few degrees (2-3 degrees). Harvest yields and changes in agricultural production as a result of climate change will however vary dramatically, both regionally and locally.

Changes in agricultural production are important considering that 800 million people currently suffer from malnutrition. As a result of population growth and increasing prosperity in some countries, the consumption of food is expected to rise by 50 per cent within 30 to 40 years compared to today.

Variation in adaptation capabilities
Biological diversity may well increase locally when new species arrive as a result of changes to the distribution areas of insects, birds and plants. But an increasing number of climate-related disturbances, in the form of the spread of diseases, insect attacks and fires, may also lead to reduced diversity.

Many species currently live in fragmented habitats. Exploited areas between these habitats form barriers and may prevent species from migrating to other habitats when the climate changes. National parks and reserves therefore need to be supplied with distribution corridors to facilitate the adjustments of flora and fauna. Species at high latitudes are the most vulnerable, since their chances of finding new habitats are limited.

Flora and fauna in coastal zones and marine environments are affected when the temperature rises. The sea freezes for a shorter of time, its salinity changes and wave-motion and water circulation are affected. The species composition of fish in certain water areas changes when habitats are affected.
The distribution of forests and forest species is expected to be affected by changes in the temperature, precipitation, extreme weather phenomena and changes in the occurrence and extent of insect attacks and fires. Effects such as irreparable damage to forests and changes in their species composition and age structure will be the result, something which in turn will have a negative impact in the long term on the possibilities of storing carbon in growing forests (acting as a sink for carbon dioxide).

The IPCC calculates that the current net uptake of carbon in land areas will probably increase during the first half of the 21st century but will then even out and gradually decrease in the latter stages.

Coastal regions hit twice as hard
A rising sea level will probably have a negative effect on human communities, tourism, freshwater reservoirs, the fishing industry, infrastructure, agricultural land and wetlands. These effects will include disappearing land areas, diminished economic value and the population displacement of tens of millions of people. Many coastal regions will be particularly badly hit.

Current estimates say the number of people living in coastal regions is equal to about half the world’s total population. The distribution varies considerably, however, from one country to the next. Not only will these often densely-populated regions be affected by a rise in the sea level, but also by flooding and an increased risk of unforeseen tidal waves in connection with powerful tropical storms.

Low-lying islands and river-delta regions are particularly susceptible to a rise in the sea level, which is also expected to lead to the loss of large coastal land areas. Low-lying island nations risk losing their entire culture when the sea lays claim to the land. These countries may well have absolutely no chance of being able to adapt to climate change.

Impact on flora and fauna
A number of recorded changes in the earth’s flora and fauna can be linked to regional changes in the climate. Such changes include the early flowering of certain trees, birds laying their eggs earlier, extended growing periods in the northern hemisphere, changed distribution limits for insects, plants and animals (towards the poles and up on to higher ground), as well as the growing problem of coral-bleaching.

Several of these so-called biological systems are certainly exposed to a different kind of impact that may lead to a change in behaviour. But the IPCC points out that the observed changes are in many cases very much in line with the climate-related reactions of the species concerned.

Entire ecosystems will be affected when individual species react to changes in the climate. A warmer climate implies changes in the structure of ecosystems, their composition, productivity and geographical dispersion. Several of these ecological effects will however not come to light until tens or even hundreds of years after the change in the climate has actually happened.

Forest regions vulnerable to climate change
The IPCC ascertains that a rising sea level will increase the vulnerability of coastal populations to flooding. An average of 50 million people a year are currently exposed to flooding as a result of storms and tidal waves. A rise in sea level of 50 centimetres would see this figure increase to over 90 million. If the sea level rises by a metre, more than one hundred million people will probably be affected. This estimate increases if we take population growth into account.
The oceans’ coral reefs are among the most species-rich marine ecosystems on Earth. They are of major importance for industries such as fishing and tourism. As wave-breakers, they buffer low-lying coastal regions and limit erosion.

These reefs, which are already threatened by pollution, unsustainable tourism and harmful fishing methods, are very vulnerable to climate change. They might be able to adapt to a slowly increasing sea level, but faced with the maximum water temperature rising over a long period of time by 3-4 degrees Celsius, they are defenceless. Widespread irreparable damage to coral reefs is the likely consequence.

Short-term temperature increases of about 1-2 degrees Celsius may cause coral-bleaching, also with devastating consequences for the reefs. Branched corals are less affected that plate or brain corals.

### Greater spread of insect-transmitted diseases

<table>
<thead>
<tr>
<th>Disease</th>
<th>Insect</th>
<th>Number of people at risk (millions)</th>
<th>Current distribution</th>
<th>Probability of increased dispersion in the event of global warming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malaria</td>
<td>mosquito</td>
<td>2 100</td>
<td>The Tropics and their periphery</td>
<td>++</td>
</tr>
<tr>
<td>Snail fever (bilharzia)</td>
<td>water snail</td>
<td>600</td>
<td>The Tropics and their periphery</td>
<td>++</td>
</tr>
<tr>
<td>Filariasis</td>
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</tr>
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<td>mosquito</td>
<td>no information available</td>
<td>tropical South America and Africa</td>
<td>+–</td>
</tr>
</tbody>
</table>

Probable +
Very probable ++

### Impact on human health

The direct effects on human health of a warmer climate include increased mortality and ill-health caused by heatwaves. In some regions where the winters become warmer, mortality would fall during the winter half-year.

Indirect effects on health include greater exposure to insect-transmitted diseases when insect distribution areas change and the insect season gets longer. Malaria, dengue fever, yellow fever and meningitis are among the diseases that are expected to spread more widely. Compared to today, 10 million more people in the future will probably live in areas where there is a high risk of malaria. Salmonella, cholera and other water or food-related diseases are also expected to increase, particularly in the Tropics and their periphery.

Effects that reduce food production in areas where food resources are often marginal as well as climate-related disturbance in economies and population displacement as a result of a rising sea level will all have a serious impact on human health.

### Coral reefs under threat when the temperature rises

The oceans’ coral reefs are among the most species-rich marine ecosystems on Earth. They are of major importance for industries such as fishing and tourism. As wave-breakers, they buffer low-lying coastal regions and limit erosion.

These reefs, which are already threatened by pollution, unsustainable tourism and harmful fishing methods, are very vulnerable to climate change. They might be able to adapt to a slowly increasing sea level,
MEASURES TO LIMIT THE EFFECTS

The IPCC’s third evaluation indicates a number of negative effects of climate change. But the report also contains some good news in the form of the existing scope for real reductions in emissions, measures that in several cases can be implemented at little or no extra cost for society.

International cooperation is seen as important. Not only will cooperation among countries and sectors keep the cost of measures down, but it may also solve competition issues and potential conflicts between business sectors in different countries concerning international trade regulations, etc.

The IPCC ascertains that many countries may well face a considerable challenge when it comes to achieving established emission targets. But it is deemed perfectly possible to go beyond such established targets by limiting emissions on a national basis and by making use of the international cooperation methods specified in the Kyoto Protocol.
Dramatic emission reductions are required

The IPCC draws attention to the fact that emissions in most countries have increased markedly in recent years. To meet the long-term challenge of stabilising levels of greenhouse gases in the atmosphere in accordance with Article 2 of the Convention on Climate Change on “dangerous interference with the climate system”, global emissions of greenhouse gases must be considerably lower than they are at present, within the very near future.

The aim of the 1992 Convention on Climate Change of development without dangerous anthropogenic interference with the climate implies the stabilisation of greenhouse gas concentrations at a level that allows ecosystems to adapt naturally, while at the same time preserving biological diversity. The world’s food production must not be jeopardised and the prerequisites for continued economic and sustainable development must exist.

8. It will take time for the effects to diminish

The climate system reacts slowly to reduced emissions of greenhouse gases. Both the temperature and the sea level will continue to rise for a century or more even after greenhouse gas concentrations have been stabilised.

9. IPCC scenarios for the stabilisation of carbon dioxide

a) Irrespective of the level, dramatic reductions in emissions are required to stabilise carbon dioxide levels in the atmosphere. To achieve a stabilisation of carbon dioxide in the atmosphere at 550 ppm, emissions must be reduced within the next two decades and lowered under their current level a few decades later. The colour span in the figure represents uncertainty in the emission scenarios.

b) The change in mean temperature is estimated using a simple stabilisation model. The global mean temperature continues to rise, but more slowly, after atmospheric carbon dioxide levels have stabilised. The shadowed area illustrates the inaccuracy interval in the scenarios.
Important technical advancements have been made

Important technical advancements that have been achieved since the IPCC’s most recent evaluation in 1995 include technology for wind turbines, hybrid vehicles, fuel cells and the underground storage of carbon dioxide. The potential for reducing emissions with the aid of technology is deemed to be about 3.6 to 5 gigatonnes of carbon per year. This corresponds to about 50 to 70 per cent of today’s emissions. Half of this potential can be utilised before 2020 through implementing measures where revenue exceeds costs. The other half can be achieved at a cost of USD 100 per tonne of carbon.

The IPCC ascertains that a stabilisation of the carbon dioxide concentration at a level of between 450 and 550 ppm can be achieved solely through the use of currently available technology for energy recovery and greater efficiency. But the IPCC also points out that a prerequisite for such a development is that a number of obstacles of an economic, political, social, behavioural and cultural nature be surmounted. Science and development as well as the effective transfer of knowledge can play an important role in reducing global emissions in a cost-effective manner.

Some measures can be implemented at a real profit

The IPCC points out that there are measures to be implemented at a net profit. These include the removal of market and institutional obstacles and tax shift. Measures and techniques for reducing greenhouse gas emissions that will solve several local and regional problems at the same time (e.g. acidification and poor air quality both in- and outdoors) are other examples.
The increased level of carbon dioxide in the atmosphere is due both to the amount emitted and the rate at which a surplus in the atmosphere can be absorbed by plants on land or by the sea. As a result of widespread deforestation over the course of several centuries – in Europe, North America and now in the Tropics – large volumes of carbon dioxide have been stored in the atmosphere. To combat and reverse this trend is now an important part of international efforts to slow down the rate of increase of carbon dioxide in the atmosphere.

Ensuring that carbon is permanently bound in forests and soil creates what are known as “carbon sinks”. The most important sink is considered to be the carbon that is stored in forest ecosystems. Changes in forest carbon storage are calculated as the difference between forest growth and felling. The size of each individual country’s carbon sinks has become an important component in their commitments under the Kyoto Protocol. Countries with large forests such as Russia and Canada have been given far-reaching opportunities to include their forests’ capacity to bind carbon in their commitments.

Carbon sinks can slow down development

Technological development can reduce emissions

Emission reductions can be achieved through the use of technology and instruments that accelerate both development and the use of new technology in the fields of:

**Energy supply**
Here, technology is needed to render the conversion of fossil fuels to fuels and energy sources with a lower carbon content more efficient.

The IPCC also points to the scope for increased use of nuclear energy and renewable energy sources such as wind, solar power and biofuels.

**Energy consumption**
Technology is needed for more efficient energy use within a number of sectors such as industry, transport, etc., as well as more efficient energy use in dwellings and premises.

**Agriculture and forestry**
Cultivation methods can be improved in both agriculture and forestry as well as in areas intended for extensive grazing activities. This is a question of, for example, investment in the planting of new forest, in reforestation and measures to slow down the rate of deforestation in connection with felling and burn-beating. It is also a question of measures to restore agricultural and grazing land that has become unproductive, to improve the quality of fodder for ruminating animals and to promote agroforestry.

Measures and instruments are required

The IPCC specifies a number of approaches and instruments in its report that must be put in place to achieve the necessary emission reductions. It is emphasised, however, that the optimum mix of political decisions and instruments varies from country to country due to their different conditions and decision-making mechanisms.

Examples of measures that will promote reduced emissions of greenhouse gases are, according to the IPCC:

- Pricing strategies for energy (carbon dioxide tax and lower energy subsidies).
- The reduction or complete phase-out of subsidies that currently lead to increased greenhouse gas emissions (in the agriculture and transport sectors, for example).
- Incentives such as the possibility for business operators to write off investments and lower costs for the consumer.
- Development of domestic and international programmes for trading in emission rights and joint implementation.
- Voluntary programmes and agreements with industry.
- Monitoring programmes with requirements for lowest permitted levels of energy efficiency.
- Efforts to increase demand with the aim of promoting the development and use of advanced technology. Presentation of best-practice examples.
- Labelling that indicates a product’s energy efficiency
The Kyoto Protocol

The 1997 Kyoto Protocol covers carbon dioxide, methane, nitrous oxide and the industrial gases HFC, PFC and Sulphur Hexafluoride (SF6).

The Protocol states that industrialised countries must reduce their emissions and that, for reasons of fairness, developing countries have no emission reduction commitments. The so-called flexible mechanisms, along with the efficient use of carbon sinks, offer a way of implementing measures to reduce emissions where it is cheapest to do so. In accordance with the Protocol, these mechanisms shall supplement domestic measures and may not be seen as a means of avoiding commitments.

There are three flexible mechanisms in the Protocol:

1) Trading in emission rights – implies that industrial countries that emit less than they need to may sell some of this “surplus” to another country that finds it more difficult to reduce its emissions.

2) Joint implementation – industrialised countries that implement projects to reduce greenhouse gas emissions in other countries have the right to count these reductions towards their own commitments.

3) The Clean Development Mechanism (CDM) – relates to projects that industrialised nations run in developing countries to be able to count reduced emissions in their own country. As well as reducing emissions, the aim is also to contribute to sustainable development in the host country.
The question of equity between industrialised and developing countries is essential in international negotiations on measures to combat greenhouse gas emissions. One main reason is that the effects of climate change are expected to be particularly serious in developing countries in the world to reduce their collective emissions by just over 5 per cent compared to 1990 levels within the period 2008-2012. The Protocol makes it clear that industrialised countries bear the responsibility for bringing about emission reductions.

After years of negotiation, an important step towards reduced global emissions of greenhouse gases was taken in the autumn of 2001 in Marrakech. The target for global emission reductions was renegotiated to two per cent for the period 2008-2012, to give as many countries as possible the chance to participate in the agreement. The United States has not committed itself to reducing emissions and neither did it participate in the Marrakech negotiations.

As the world’s countries now start to act in order to reach the emission reduction target, international cooperation is expected to intensify. In the longer term, emissions must be reduced much more than stipulated in the commitments made for the period 2008-2012.

In parallel with the cooperation within the framework of the climate convention, a number of other important cooperation initiatives among groups of scientists, countries and organisations on different levels are already being taken. These include cooperation within the Nordic Council of Ministers, the ICLEI’s Cities for Climate Protection campaign, the World Energy Council and the Climate Action Network.

The majority of international cooperation among the countries of the world is done within the framework of the 1992 UN Convention on Climate Change. The 1997 Kyoto Protocol supplements the Convention and specifies targets, methods and guidelines for how emissions are to be reduced. The aim is for all the countries in the world to reduce their collective emissions by just over 5 per cent compared to 1990 levels within the period 2008-2012. The Protocol makes it clear that industrialised countries bear the responsibility for bringing about emission reductions.

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The IPCC ascertains that climate change jeopardises poor people’s chances of fleeing poverty because it will:

- Seriously affect nature resources such as agriculture, forests, fish stocks, coral reefs and mangrove regions. This is where many poor people currently manage to support themselves.
- Reduce access to and negatively affect drinking water quality. The effects in regions that are already dry will be particularly serious.
- Seriously affect human health as a result, for example, of less food being available and the greater risk of the spread of insect-transmitted and waterborne infectious diseases.
- Increase the population’s vulnerability to ecological impoverishment and natural disasters such as floods and drought.

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The question of equity between industrialised and developing countries is essential in international negotiations on measures to combat greenhouse gas emissions. One main reason is that the effects of climate change are expected to be particularly serious in developing countries with the risk of aggravating differences in welfare between industrialised and developing countries as a result. Climate change reduces the scope of developing countries for alleviating poverty and achieving long-term sustainable development.

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The message from the UN Intergovernmental Panel on Climate Change (IPCC) is clear: there is no longer any doubt that we really do contribute to global warming.

Clear facts about Climate Change is a summary of the current state of scientific knowledge regarding the earth’s climate and how it is affected by humans. The report describes how society’s vulnerability, ecosystems and human health are affected when the temperature rises. But this threat of serious climate change can be confronted. The increase in the average temperature can be limited – provided that measures to reduce greenhouse gas emissions are taken. The IPCC describes a number of possible scenarios.

The IPCC consists of several hundred scientists drawn from different disciplines the world over. The task of the Panel is to carry out regular analyses and evaluate research into climate change and its conclusions act as a basis for impartial decision-making.

Clear facts about Climate Change is a summary of the IPCC’s third evaluation report from 2001. You can read more about the IPCC and its activities by visiting www.ipcc.ch.