



Federal Ministry for the  
Environment, Nature Conservation  
and Nuclear Safety

# COMBATING CLIMATE CHANGE

The German  
Adaptation Strategy



# IMPRINT

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# CLIMATE PROTECTION AND ADAPTATION TO CLIMATE CHANGE – THE TWO PILLARS OF GERMANY'S CLIMATE POLICY





The climate is changing worldwide – and so are our living conditions. If we do not succeed in slowing the pace of global climate change, experts expect far-reaching consequences for the environment, society and the economy. That is why Germany, together with the member states of the European Union (EU), is seeking to contain the rise in mean global temperature. Experts consider that two degrees Celsius above pre-industrial temperature levels is an acceptable maximum for keeping the consequences manageable. If this is to be achieved, climate-relevant emissions of greenhouse

gases must be reduced worldwide, by the industrialised countries in particular.

But climate change has already started. Even if we succeed in meeting the two-degree target, many things will no longer be the same as before. Ecological, social and economic consequences are already making themselves felt in many regions, and they will probably increase in the years ahead.

To minimise the adverse effects, we first need to step up climate protection. Secondly, we need to take precautions in the form of

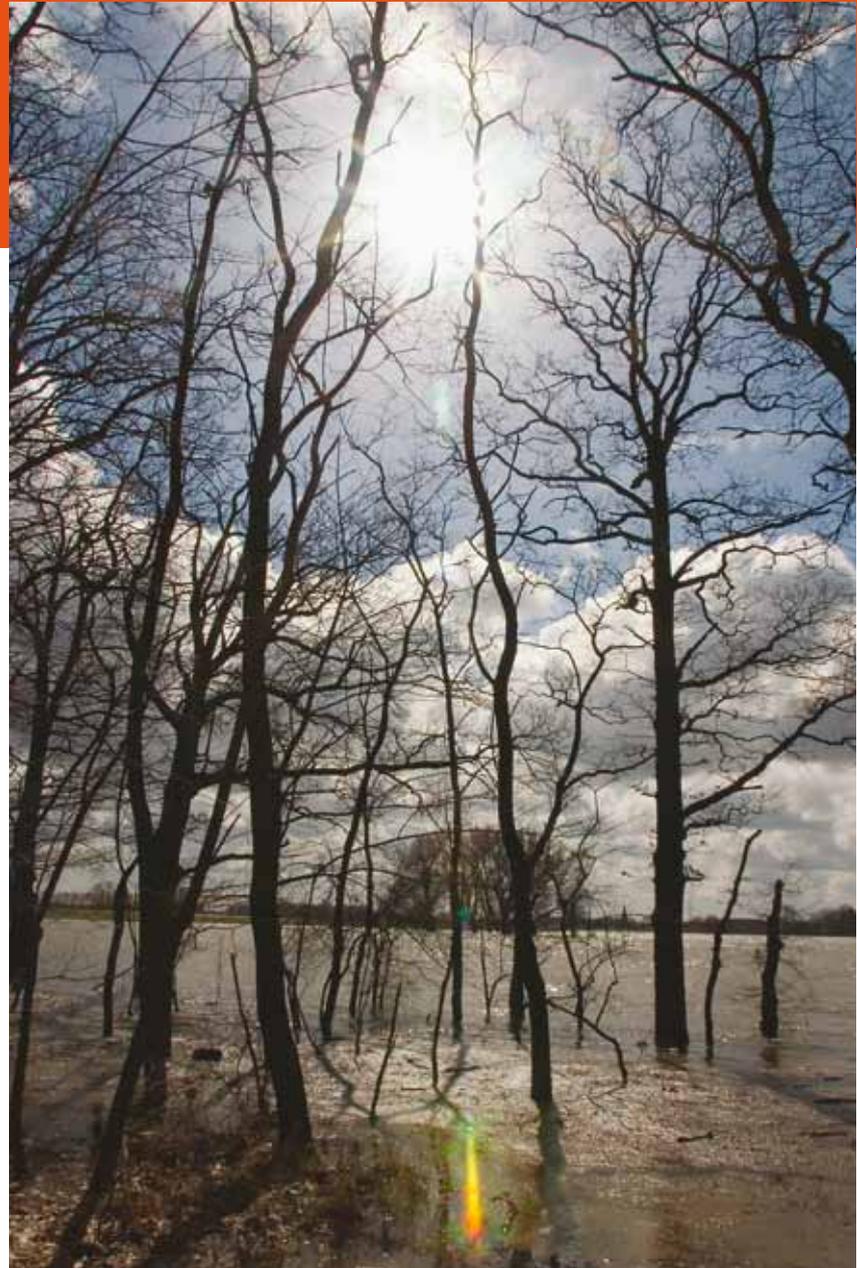
adaptation: the adverse effects of foreseeable changes on society and nature should be kept to a minimum. It is therefore important to reduce their vulnerability (see Glossary - Vulnerability) and help them adapt flexibly to the new situation. Also, we must not fail to take advantage of the opportunities that climate change opens up for certain areas. For example, new openings could emerge in the fields of tourism, agriculture and environmental technology. Taking appropriate and timely action, e.g. through far-sighted planning and construction, not only prevents avoidable



damage. It also saves future generations from having to make even greater efforts to achieve the same results.

In view of all this, one thing is clear: adaptation measures are no substitute for climate protection. If temperatures in the global greenhouse increase, the cost of adaptation measures will also increase. Conversely, it is also true that keeping down the amount of harmful greenhouse gases that escape into the atmosphere helps to keep down the cost of adaptation. **To this extent there is an inextricable connection between climate protection and adaptation: they are two sides of the same coin, and form the two pillars on which Germany's climate policy is built.**

Whereas climate protection involves quantifiable targets – namely the quantity of greenhouse gas emissions to be reduced – the target of adaptation measures is less easy to express in concrete terms: the important consideration here is to reduce the vulnerability of natural, social and economic systems. It also seeks to improve their capacity to adapt to new situations.



These are complex demands, in which not only a large number of actors and decision-making levels have a role to play. There are also interactions between different sectors such as agriculture and water management, which means that benefits for one area may give rise to undesirable side-effects elsewhere. As a result, it is not only necessary to identify the interactions, but also to weigh up any advantages and disadvantages that arise.

This will frequently lead to a need to rewrite the original plan. For this reason it is essential that all concerned are aware of what the others are doing and what goals they are pursuing. Only then is it possible to identify and resolve conflicts. Particularly because the problem is so complex, it is absolutely essential to take a structured approach and ensure transparency.



## The Federal Government is showing the way

A structured process of this kind is what the Federal Government is seeking to promote in the German Adaptation Strategy (DAS). By signing the UN Framework Convention on Climate Change in 1992, it undertook to develop and regularly update a national adaptation plan.

The Federal Government sees the German Adaptation Strategy as a medium-term process in which the federal, Länder and local authorities and many other actors in society join forces to identify where what action is needed to prevent adverse effects in the future. It is then to be taken as a basis for developing and implementing specific measures.

Other European states are taking a similar approach, and the EU Commission has announced a White Paper on Adaptation for April 2009. This White Paper – based on the fundamental ideas in the EU Commission’s Green Paper of June 2007 – is to set out concrete details of tasks and action options at the level of the European Union.

In drawing up the Adaptation Strategy the Federal Government is basing its approach on the following principles:

## The Federal Government in dialogue

Managing the consequences of climate change is a task for society as a whole, and accordingly the responsibility for it rests on many shoulders. The German Adaptation Strategy is to structure the process and indicate where the federal level sees priorities. The regional level (federal states, or “Länder”) is already playing an active role in a variety of areas, and some Länder have already drawn up guidelines for action (see Information available on the Internet, p. 70/71). In the German Adaptation Strategy the Federal Government suggests what form the dialogue could take.

## Ongoing research and immediate action

To make plans and take precautions, one needs comprehensive information. This applies to private persons, scientists, businesspeople, civil servants and politicians alike. They need sound and regularly updated research findings so that they can develop measures to adapt to climate change: What changes are likely to affect specific regions, what threats exist, and what is the probability that these risks will occur? This

means that information and data must be prepared in a comprehensible form, and made readily available and accessible on a targeted basis. It should also be clear what countermeasures are possible and who is responsible in each case.

In considering how the global climate will change, the Federal Government is currently basing its approach on the forecasts made by the Intergovernmental Panel on Climate Change (IPCC) in its Fourth Assessment Report in 2007. The probable picture for individual regions, by contrast, is far less clear. But even here it is nevertheless possible to describe trends at this level, because different models have come to similar conclusions.

This report undertakes a synoptic situation review indicating what consequences can be expected for humans, the economy and the environment. It makes it evident that there is still a need for considerable further research. But even if we have to perform our calculations with several unknowns, “wait and see” is not an option. If we are to be prepared, we have to take adaptation measures now. What is important is that they should be of sufficiently flexible design to ensure that they function over a wide range of climate effects and can be adapted to future findings and needs.

## Made to measure – preferably on a local basis

For many industries and regions in Germany, climate change opens up new opportunities, while others will be confronted with serious challenges. Accordingly, the adaptation measures must be different in different places. People on the spot often know best what is good for their specific case; in such cases the federal level can play a largely supporting role. The Federal Government is therefore relying on strengthening individual responsibility and adaptive capacity at the local level.

## Several birds with one stone

Adaptation measures should be cost-effective, and their cost should bear a reasonable relationship to the risks from which they are designed to protect us. Furthermore, they should not be developed in isolation, but should wherever possible pursue other meaningful objectives at the same time. After all, “one man’s meat is another man’s poison”. For this reason, all measures must constantly bear in mind that they may also have impacts on other areas of life and economic activity. The ideal result of timely dialogue is a solution that is good for all, or at least not actually bad for anybody.

## Assuming international responsibility

In many parts of the world, climate change will have much more severe consequences than in Germany. At the same time people in developing countries in particular are in a far worse position than we are to protect themselves. Adaptation is therefore becoming an increasingly important aspect of bilateral and international cooperation. In addition to worldwide reductions in greenhouse gas emissions, adaptation has come to occupy a leading position in the list of priorities for internal climate negotiations.

Today, the adaptation aspect also plays a central role in cooperation on development, security and environmental policy. If more people leave their home countries permanently as a result of increasing storms and floods, or in response

to frequent droughts, this has a direct impact on migration policy. The German Adaptation Strategy deals with these issues as well.

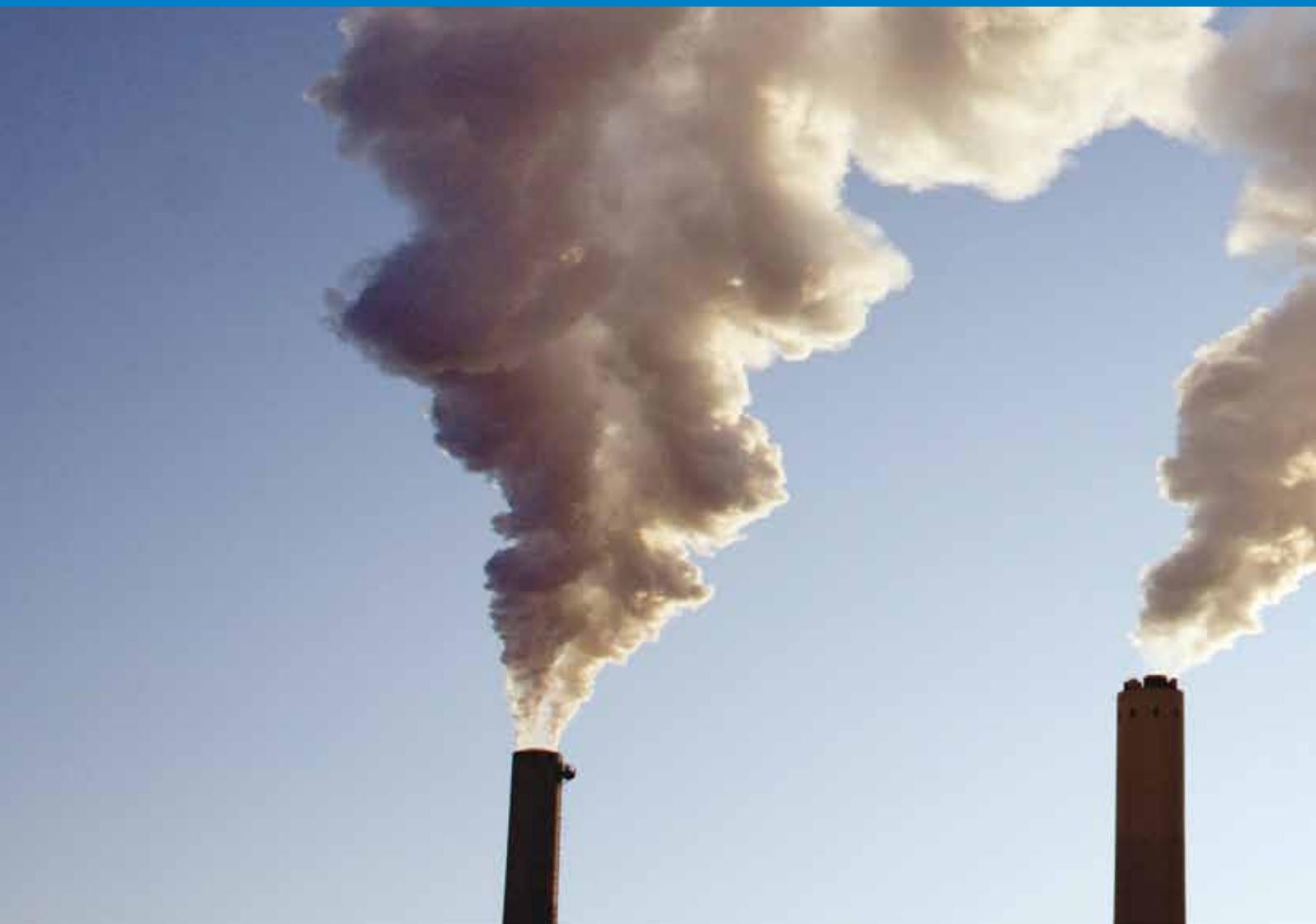
## Sustainability and adaptation are complementary

The German Adaptation Strategy is part of the Federal Government’s Sustainability Strategy, and is embedded in it. Sustainability and adaptation are complementary. This is particularly evident when it comes to “Climate and Energy” – one of the four key areas in the Federal Government’s latest progress report on the National Sustainability Strategy. But the German Adaptation Strategy is an important factor for other policy areas as well. These include the conservation of biological diversity or the promotion of rural areas, to mention only two examples.





**MAN IS INFLUENCING THE CLIMATE**





## 2.1 Already changed: the global climate

Over the past 100 years, the Earth has become a warmer place. Since the beginning of the 20th century, the global mean annual temperature has risen by 0.74 degrees Celsius ( $^{\circ}\text{C}$ ). The Intergovernmental Panel on Climate Change, or IPCC, says there is a “very high probability” – i.e. a probability of over 90 percent – that this is due to hu-

man activities. Especially since 1950, the curve shows a steep upward trend. Mean temperatures in the northern hemisphere in the second half of the last century were very probably higher than for any other 50-year period in the past 500 years. They probably exceeded the figures for the last 1300 years or an even longer period. (Source: Intergovernmental Panel on Climate Change, IPCC 2007, SPM WG I, p. 10, German edition) Mountain glaciers and snow cover are shrinking all over

the world, and sea level has risen by an average of 17 centimetres in the course of the 20th century.

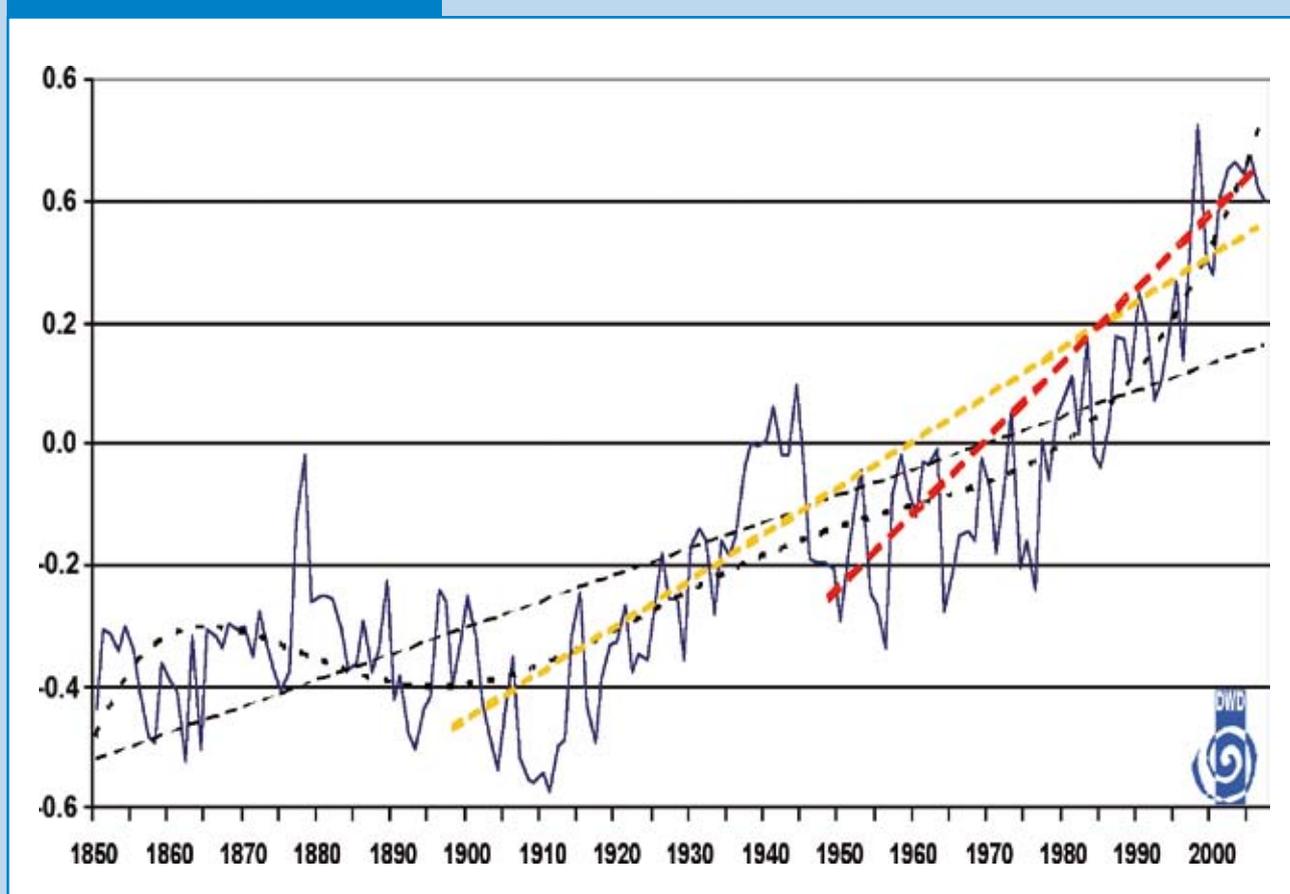
### What the IPCC expects

If people continue to emit climate-relevant gases into the atmosphere without any restrictions, scientists expect mean temperatures to rise by between 1.8 and 4.0 degrees Celsius ( $^{\circ}\text{C}$ ) by the end of the century – indeed, some sci-

#### Mean temperatures 1850-2005 (Figure 1)

This shows how global mean temperatures have developed from 1850 to 2005 (blue line). The linear trend since 1850 (black line), 1900 (yellow line) and 1950 (red line) is becoming steeper and steeper. The trend curve (polynomial fit of the time series) shows the dramatic rise since the end of the 1970s (black curve).

Data sources: [www.metoffice.gov.uk/hadobs](http://www.metoffice.gov.uk/hadobs) and German Weather Service (DWD)





Rainfall intensity and distribution are also very likely to change: while higher latitudes will probably become wetter, rainfall in most subtropical land regions is likely to decrease. This would maintain the trend that can already be observed.

entists believe a rise of 6.4 degrees Celsius is possible.

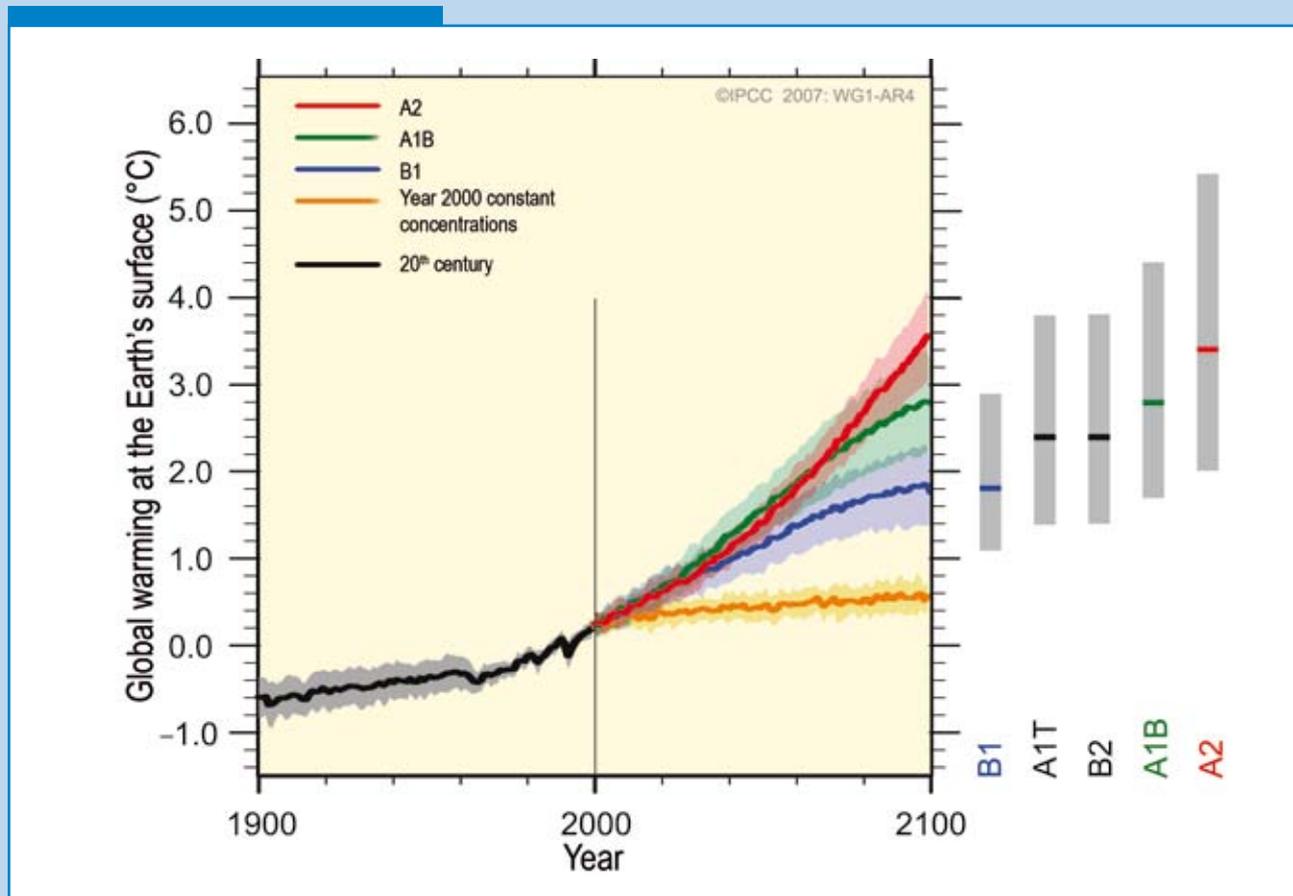
Warming will probably be greatest over the continents and in the polar regions. The ice in the Arctic is continuing to melt, and some

models expect it to disappear almost completely during the summer season in the second half of this century. Partly as a result of this, there could be a rise in sea level of between 18 and 59 centimetres by the year 2100.

Moreover, the various climate models predict that there could be an increase in both the frequency and intensity of heat-waves, local intense rainfall and cyclones.

### Surface warming scenarios (Figure 2)

This shows the extent of global surface warming according to scenarios A2, A1B and B1 (see Glossary - SRES scenarios). If greenhouse gas emissions had been frozen at the level of the year 2000, the curve could have been expected to follow the orange line. The grey bars on the right indicate the probable bandwidth of the rise in temperature forecast by the six SRES scenarios. [IPCC 2007].



## 2.2 Climate change in Germany

Mean annual temperatures in Germany have risen by nearly 0.9 degrees Celsius (°C) since 1901. From 1990 to 1999 meteorologists recorded the warmest decade of the entire 20th century. Especially in the south-west of Germany, thermometers registered higher figures – Saarland recorded a rise of 1.2 degrees Celsius in mean annual temperature. By contrast, Mecklen-

burg-Western Pomerania measured a rise of only 0.4 degrees Celsius.

It is also raining more these days. Meteorologists have found that precipitation has increased by about nine percent since the beginning of the 20th century. The past 15 years have been particularly wet – with only four exceptions.

Today water butts are filling up much faster in spring up to June, though July and August are drier

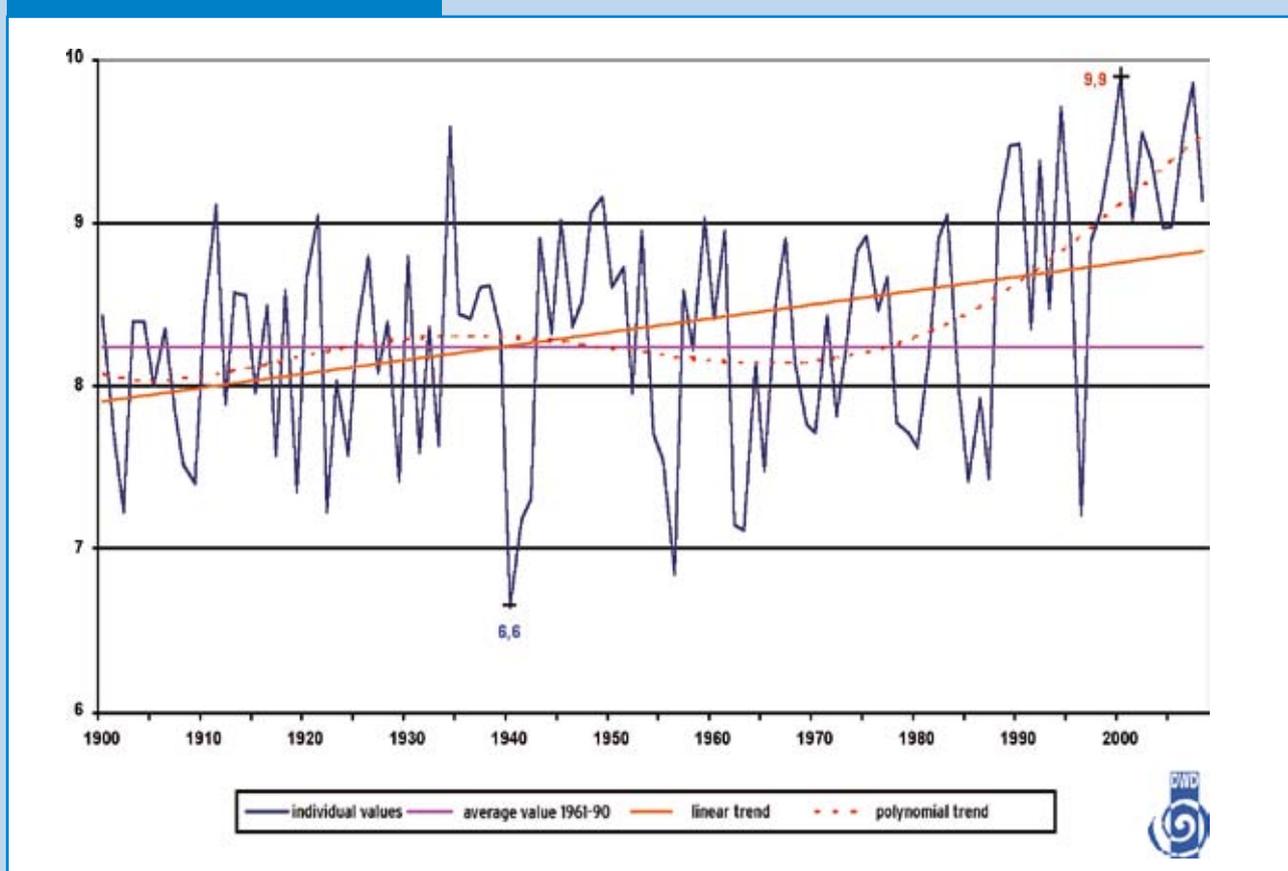
on average. Although researchers have also registered more rainfall in the winter months, the great variations from year to year mean that no statistically significant picture has emerged yet.

There are also considerable regional differences. For example, total rainfall in the west of Germany has shown an increase in recent years, but in the east it has hardly changed. However, in the east it is now raining more in the winter – and less in the summer.

### Mean temperatures 1961-1990 in °C (Figure 3)

This shows how mean annual temperatures developed in Germany (blue curve), and also the linear trend (orange line) and the trend curve (dashed red line). The mean for the years 1961 to 1990 is taken as the base value for calculating deviations (pink line).

Source: DWD, 2007, [www.dwd.de/presse](http://www.dwd.de/presse)





## Looking into Germany's future

And what are the prospects for the future? The global climate models are not fine enough to be used as a basis for precise regional forecasts. The horizontal

grid separation is at least 120 kilometres, and in some places the gap is actually more than 200 kilometres. For this reason, regionalisation methods are used. Some take observed climate data from climate stations and project it into the future, while others use nu-

merical physical methods to refine the global calculations and obtain a finer-meshed grid with a minimum separation of 10 kilometres. The four regional models currently used in Germany are REMO, CLM, WETTREG and STAR.

### Surface warming in °C by scenarios (Figure 4)

This shows how the mean annual temperature in Germany changes according to the calculations of the regional models REMO and WETTREG under scenarios A2, A1B and B1 (see Glossary - SRES scenarios) - by comparison with the mean for the years 1961 to 1990. (Input data from the global model ECHAM 5.)

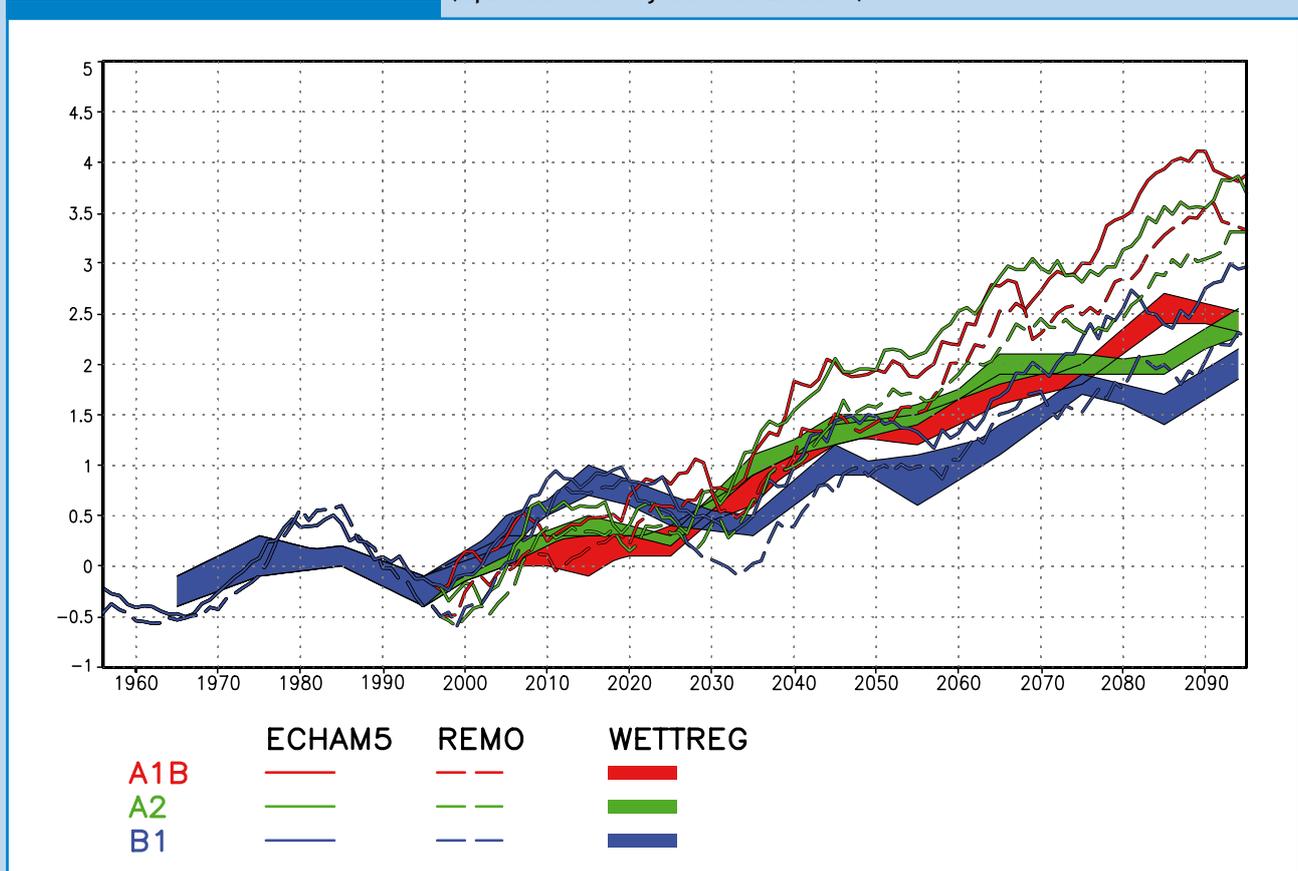


Figure 4 shows the temperature rises predicted for Germany by the two regional models (REMO and WETTREG). Here the climate researchers have worked on the basis of the same three IPCC emission scenarios in each case, which makes it possible to compare the results. The trend is clear: it will very probably become warmer, especially in winter. The size of the rise will depend largely on the extent to which human beings continue to heat the global greenhouse. Experts expect mean annual temperatures to increase by 0.5 to 1.5 degrees Celsius in the period 2021 to 2050. In the last 30 years of this century, the tempera-

tures could be as much as 1.5 to 3.5 degrees higher than in the reference period 1961 to 1990.

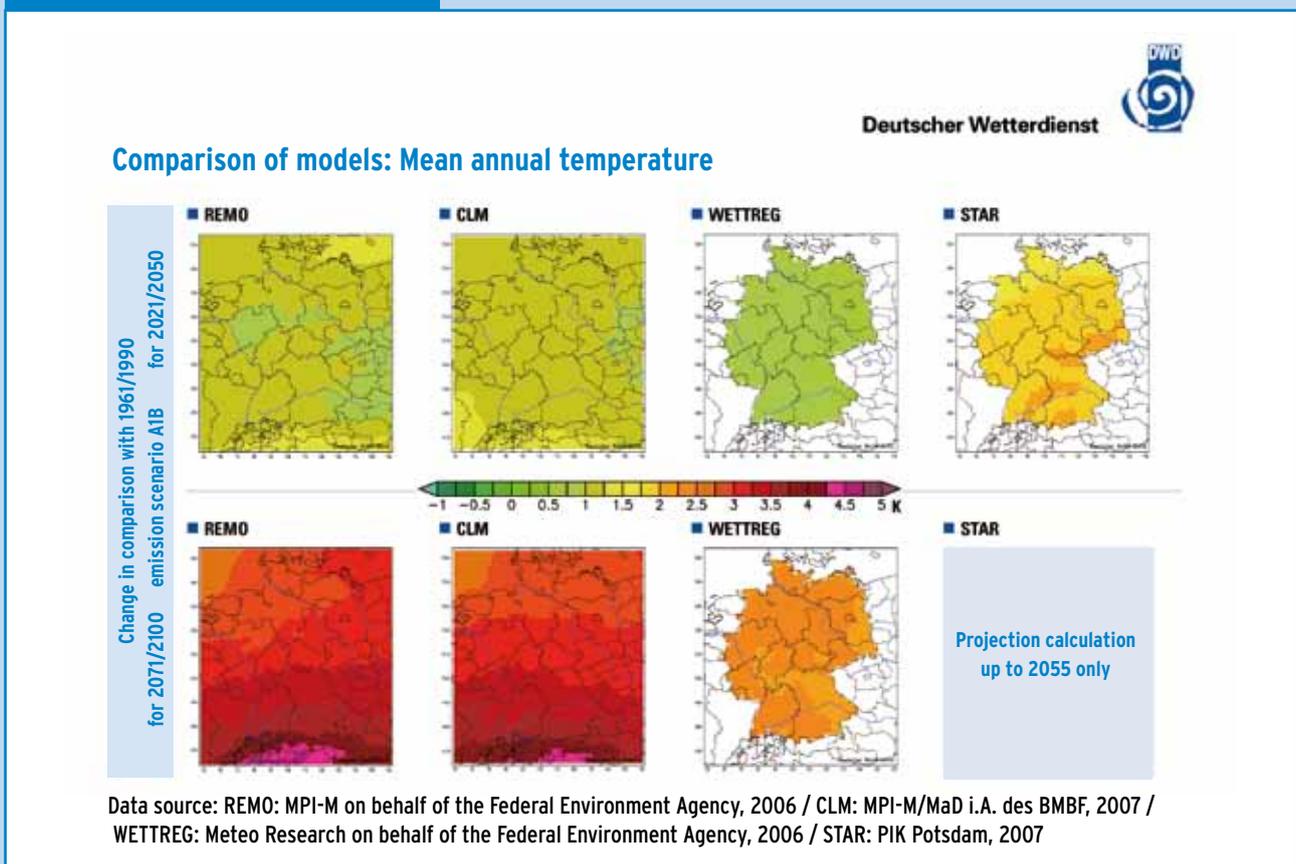
The effects of climate change could be particularly marked in the case of rainfall. Although taken over the year as a whole the quantities will probably remain relatively constant, we could find that there is up to 40 percent less rainfall in the summer. Here again, the south-west could be especially hard hit. Winters, however, could – depending on the model – bring between zero and 40 percent more rainfall. Indeed, the WETTREG model actually indicates that in the winter seasons

towards the end of this century there could be up to 70 percent more rainfall in the central upland regions of Rhineland-Palatinate, Hesse and the north-east of Bavaria.

The comparative studies of WETTREG and REMO expect temperatures in excess of 30 degrees to occur on three times as many days as between 1961 and 1990 (see [www.umweltbundesamt.de/klimaschutz/index.htm](http://www.umweltbundesamt.de/klimaschutz/index.htm)). The experts also expect that cloudbursts could bring even more intense rainfall than at present. Where storms are concerned there are still too many uncertainties to permit clear forecasts.

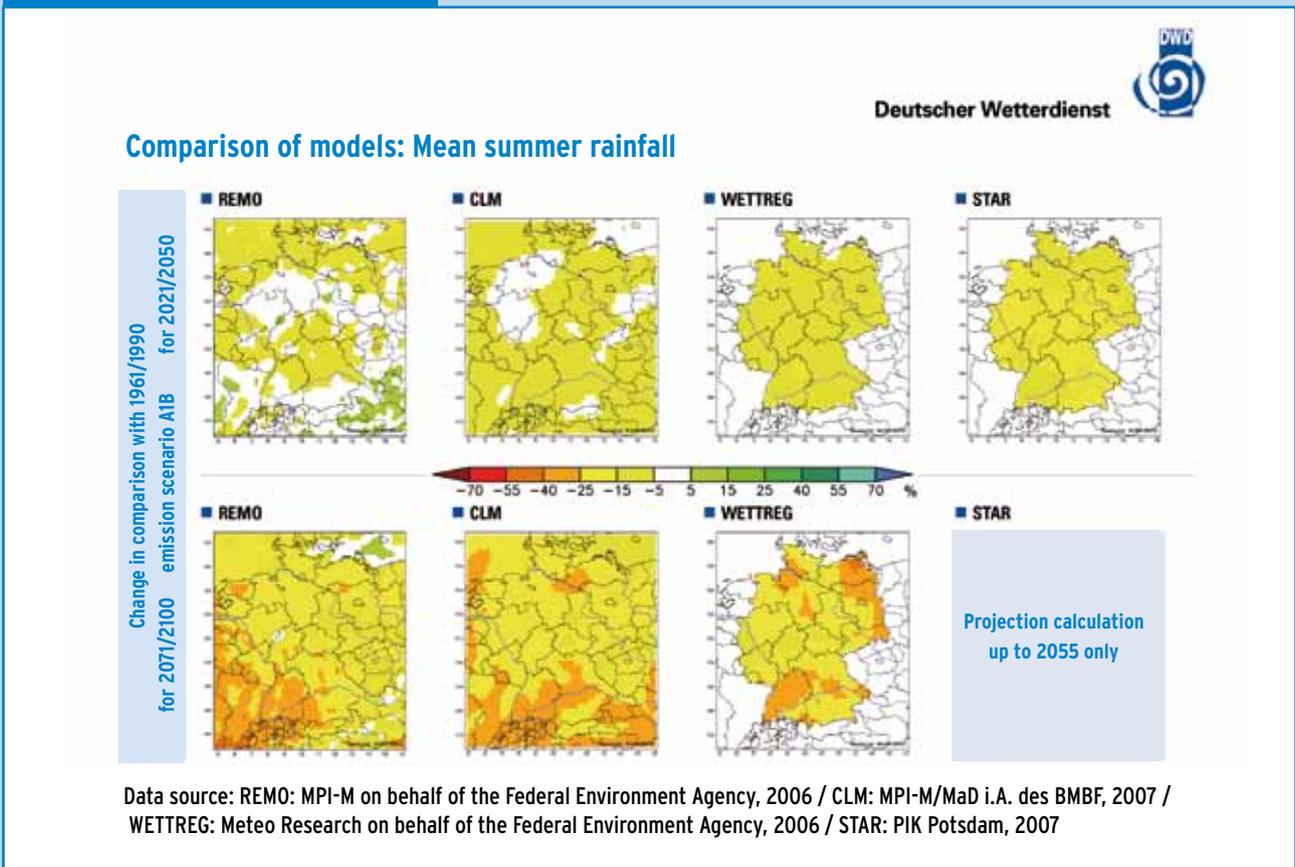
### Comparison of model calculations: Mean annual temperature (Figure 5)

This figure shows the changes in mean annual temperatures predicted by the regional climate models REMO, CLM, WETTREG and STAR, assuming that mankind emits the amounts of greenhouse gases in scenario A1B. The upper diagrams show the calculations for the period 2021 to 2050, the lower diagrams for the period 2071 to 2100. The baseline (zero) is calculated from the reference period 1961 to 1990.

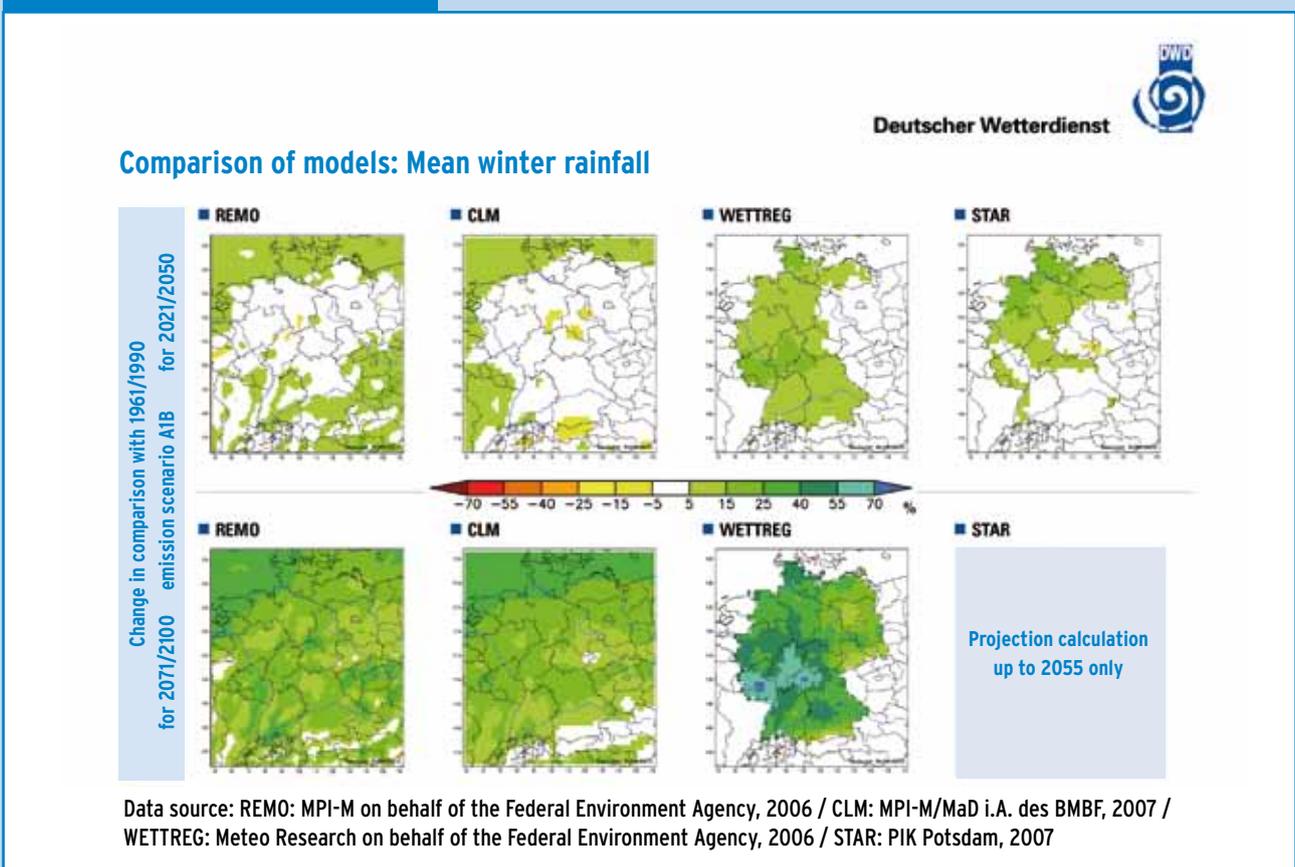


### Comparison of models: Mean summer rainfall (Figure 6)

This shows how summer (Figure 6) and winter (Figure 7) rainfall could change in the regional climate models REMO, CLM, WETTREG and STAR if mankind emits greenhouse gases on the scale assumed in scenario A1B. The upper diagrams show the forecasts for the period 2021 to 2050, the lower diagrams for the period 2071 to 2100. The baseline (zero) is provided by the means for the years 1961 to 1990.



### Comparison of models: Mean winter rainfall (Figure 7)



## 2.3 Dealing with uncertainty factors

The author Mark Twain is said to have stated that “The art of prophecy is very difficult, especially with respect to the future”. Anyone who talks about the future always has to take account of uncertainties. In the case of global and regional climate models this means that several factors which are difficult to estimate could cancel each other out in the end – or have a cumulative effect.

The amount of greenhouse gases emitted into the atmosphere in the future will depend on a large number of influences and cannot therefore be predicted. Factors that play a role here include how the population, the economy and energy prices develop, the way land is used, and the extent to which technologies for minimising greenhouse gas emissions become established. Moreover, it is not yet possible to make any reliable statements about the impact that individual greenhouse gas emissions have on the climate.

In order to deal with such uncertainty factors and nevertheless remain in a position to take action, agreement has been reached on certain emission scenarios defined by the IPCC. These scenarios describe potential developments in human society and our environment. They form the boundary conditions for climate modelling. But one thing is clear: The models can never be more than approximations to reality, since in real life the climate is far more complicated. It is impossible to represent all the factors that go to make up the system we call “climate”.

The further one looks into the future, and the smaller the regional focus, the more uncertain the forecasts become. The probability of making a correct forecast is, however, increased if it is possible to superimpose several models. In Germany there are four regional models that have each been used to calculate three emission scenarios. Further calculations will follow.

## What approach is the Federal Government taking?

In its planning and decisions, the Federal Government will take account of the ranges and uncertainties that exist, and will not rely on the results of individual models. A synoptic view of various model results will provide the basis for decisions. As a result of social change and climate change, global change is taking place very rapidly. This means it no longer makes sense to use the past to draw conclusions about the future, as was sufficient in the past. Today it is essential to take account of probable and possible future developments. The Federal Government will design the adaptation process so that there is a good probability of achieving its goals despite differences in the way the climate develops.



## What future planning should look like – for example in the water management sector

Preference should be given to measures that are flexible and that permit follow-up control. For example, technical flood control– e.g. using dykes – should be supplemented by flood control precautions. This includes appropriate building in flood-prone areas, allowing rainwater to seep away, and setting up flood warning systems.

Steps should also be taken to promote measures that alleviate the effects of extreme events such as floods and low water. This is possible by reconnecting old river branches or setting dykes further back from the water.

And finally, efforts should be made to achieve synergies – in other words to take advantage of the fact that different factors can work together and that one measure may have desirable effects in different areas. For example, giving water more space by keeping areas free of building or surface sealing promotes groundwater recharge. At the same time this helps to ensure that floods do not receive additional input in the form of direct runoff from sealed surfaces, or that no additional assets such as houses or businesses are sited in areas subject to flooding.



Danube with old river branch



# THE CONSEQUENCES OF CLIMATE CHANGE - WHAT CAN WE DO?







## Climate change makes itself felt in many ways

- ▶ Some changes due to climate change develop gradually and therefore tend to be felt mainly in the medium term: trees blossom earlier in the year, and birds breed earlier. In many regions people are already having to heat their houses less in the winter.
- ▶ Intense rainfall, storms and storm surges, extreme heat and long periods of drought will probably occur more frequently and in more extreme form than in the past, and could result in more floods or low water, forest fires and heat stress.
- ▶ And finally, there is likely to be an increase in climate variability (see Glossary – Climate variability). This means that variations in climate over time and space will increase. This too can cause enormous damage in the medium term, for example if droughts occur so frequently that they overstrain the capacity of agriculture and forestry to cope.

The consequences of climate change show very wide regional variations and may have not only negative, but also positive impacts. Prolonged periods of drought are a threat to harvests, but new climatic conditions may favour varieties for which conditions were previously too wet or too cold. Higher mean temperatures are expected for the North Sea and Baltic Sea coasts of Germany, and the tourist industry is looking forward to a longer season. At the same time the winter season in the Alps is threatened by lack of snow, and the focus is shifting to other forms of tourism.

However, the way the economy, society and the environment develop depends not only on climate change, but also on other long-

term changes, e.g. population development or settlement structure. Since such factors also influence each other, it is absolutely essential to take account of this



fact in the various policy sectors. It is important to take a holistic approach to the effects of climate change and to developing relevant solutions. The focus here should always be on sustainability, in other words on finding solutions that are viable for nature, society and the economy.

## 3.1 Impacts on nature and society

Climate change can have a wide variety of effects. To date, these effects can often be described in qualitative terms only – i.e. not with measurable data – or predicted by means of model assumptions. There is therefore a need for long-term climate impact monitoring to identify changes. Whether adaptation measures are successful is something that can also only be checked with the aid of reliable data series.

## German Länder have developed a biomonitoring system

Headed by Schleswig-Holstein, Baden-Württemberg and Hesse, the Länder have developed a climate biomonitoring system. It is designed to ensure that early warning signals are noticed and that associations or other interests parties can use data collections and analyses to carry on follow-up work.

In 2006 the concept was agreed with all the Länder, the Federal Environment Agency, the Federal Office for Nature Conservation and the German Weather Service. The tried and tested methods of observation form a sound and suitable basis for practical work. Work is already in progress on concrete projects in several Länder.

### Our health

It is possible that climate change could result in an increase in both infectious diseases and non-infectious diseases such as circulation disorders and allergies. There is also reason to fear that more injuries will occur if extreme weather events – such as storms and floods – become more frequent.

### Spread of infectious diseases

Not only existing pathogens can spread better in a mild climate. Pathogens that are not yet native to Germany could also become established here. As temperatures rise, food can perish faster, leading to more frequent gastro-intestinal infections – for example caused by Salmonella.

Existing pathogens that could spread better in a milder climate include Hanta virus, which is transmitted by rodents, frequently bank voles. Infections caused by excrement from such animals can lead to fever and range up to kidney failure. Another example is Borrelia or spring-summer encephalitis (TBE) viruses, which are transmitted by ticks. Milder annual temperatures can provide more favourable living conditions for such organisms.

A milder climate could also result in the “Asian tiger mosquito”, for example, becoming established in Germany; this can transmit various viruses including dengue fever.

The pathogen responsible for leishmaniasis, which is transmitted by sand flies, has already been detected.

### Extreme weather conditions and non-infectious diseases

People may be injured or even killed by intense rainfall, floods, storms, avalanches and landslides. In the heat-wave summer of 2003 some 7,000 people in Germany

alone died of heart attacks, cardiovascular diseases, kidney failure, respiratory problems and metabolic disorders as a result of heat-induced stress.

Mild temperatures combined with nutrient accumulations favour the growth of toxic blue-green algae on the Baltic coast and in lakes. Contact with such blue-green algae may not only lead to irritation of the skin or the gastro-intestinal tract, but may also cause serious liver damage.



Another possible effect of climate change could be an increase in allergic disorders, especially those arising from changes in the distribution of pollen. In 2007 the Federal Ministry of Food, Agriculture and Consumer Protection launched an action plan against allergies with the aim of making everyday life easier for allergy sufferers. Here special mention must be made of the Ambrosia programme coordinated by the Julius-Kühn Institute (JKI) (see [www.jki.bund.de/ambrosia](http://www.jki.bund.de/ambrosia) – German only).

There is also reason to expect an increase in the incidence of respiratory problems, favoured by ground-level ozone during high-pressure situations in summer. Furthermore, the risk of skin cancer could be increased by more

sunshine. And finally, negative changes affecting recreation areas and the urban climate can also have adverse effects on individual well-being. At present, however, it is not possible to tell the extent to which atmospheric warming has or will have an influence on non-infectious diseases in Germany.

### Precautions require information

In order to keep the risks arising from introduced pathogens under control, sectoral authorities and research institutions need to work together and take joint precautions. This is not only a question of adapting the existing monitoring systems; it is also necessary to understand the behaviour and propaga-

tion of climate-sensitive pathogens or their vectors in Germany. On the basis of this information, experts must consider how they can improve the detection of such infections, what is the best way to treat infected persons, and whether it is possible to develop vaccines.

In the case of non-infectious diseases it is important to bear in mind that as a rule they cannot be attributed entirely to the effects of climate change. Individual health can also be influenced by personal lifestyles and individual health habits, such as eating and exercise habits, tobacco and alcohol consumption, or noise levels in residential areas. To be able to assess the adverse effects of climate change on human health and take effective countermeasures, there is therefore a need to obtain and analyse data on a targeted basis and to communicate important findings to specialists and the general public.

In addition, the federal authorities and the Länder should provide not only the general public and individual risk groups such as children and senior citizens, but also multipliers such as medical personnel, nursing staff and disaster control personnel, with information about possible basic precautions against climate change effects. For example, more information should be provided about how to avoid heat-induced damage to health. At the request of the federal authorities, the Robert Koch Institute is looking into such issues. Furthermore, the effects of climate change are taken up in the Environment and Health

Screening for skin cancer





Action Programme (APUG). This action programme is run by the three federal ministries that are responsible for the environment, health and consumer protection. ([www.apug.de](http://www.apug.de) – German only) In particular, central objectives of this programme include informing the public and improving cooperation between the competent authorities.

Well-functioning early warning systems reduce the risk of harmful effects on individuals. The German Weather Service (DWD) informs the Länder – and the administrative districts, if need be – about forthcom-

ing heat-waves or imminent intense rainfall. The flow of information must be further improved to ensure that such information reaches hospitals, crèches and the disaster control authorities in good time.

### **Health needs good surroundings**

Architecture and urban and landscape planning have a great influence on whether heat accumulates – especially in built-up areas. To prevent heat stress, unobstructed fresh-air corridors without

buildings should exist especially in urban agglomerations. Green spaces can also function as “cold islands”. Local authorities should therefore refrain from sealing free surfaces by creating new streets, car parks and buildings.

Furthermore, hospitals, nursing homes and retirement homes in particular must ensure that their buildings are adequately insulated against heat and cold, and that they possess climate-friendly – i.e. preferably passive – cooling facilities.



Low-energy building in North Rhine-Westphalia

## Building sector

Lengthy heat-waves, intense rainfall, cloudbursts and severe storms can all present a direct threat to buildings, bridges, roads and sewage systems. By contrast, it is not possible at present to assess what more frequent damp winters and more summer sunshine mean for buildings. Another factor that will play an increasing role in future is how reliable and flexible certain building materials will prove in their response to heat. This not only has to be considered in new buildings. It will also be necessary to make a critical review of existing buildings.

## Looking 100 years ahead

Standards of construction planning, building technology and execution are high in Germany. The requirements are different for different regions and localities – depending on what demands the climate places on specific structures. If any changes should take place here, the relevant provisions can quickly be updated. In any case DIN standards are examined every five years to see whether they need to be revised.

On the other hand, standards in the construction sector are still based on observed data from the

past. They do not yet take account of forecasts about future developments. However, since buildings and infrastructure facilities are frequently used for more than a hundred years, the federal and Länder authorities should adapt the standards to take account of climate change.

In addition, the possible consequences of climate change should also be considered when planning new buildings or purchasing new technical equipment for a building. Whereas there is likely to be a continuing need to heat buildings in winter – albeit on a smaller scale than in the past –, in summer it will probably be necessary to protect top-floor flats and rooms in particular from overheating. Thermal insulation and shading elements should be provided. Together with optimum building orientation they can keep temperature within reasonable limits even at times of great heat, making it possible to manage without energy-intensive air-conditioning systems. Another forward-looking possibility is controlled ventilation systems of the kind already found in passive houses.



Floating house

## Water regime, coastal and marine protection

There are a number of ways in which the water regime in Germany could be affected by climate change: in the medium term we can expect changes in water quantities and water quality. Changes in the annual distribution of rain and snow will lead to changes in groundwater levels and differences in flow rates. If water levels in streams and rivers change, this also has an influence on water quality – which has to be borne in mind because of fish and other forms of life, and also in connection with the treatment of drinking water. There is also likely to be an increasing risk due to extreme events such as floods, storm surges or droughts. And finally this could intensify the existing regional differences in the amount of water available.

The interactions between uses of water are complex. There are consequently great differences in the extent to which the water sector, flood control and coastal protection will have to adapt to climate change. Responsibility for implementation in all these fields rests with the Länder.



Dyke construction at the Elbe

## Consequences for the water regime

- ▶ Intense rainfall events are expected to become more frequent and more extreme. This probably means an increase in the risk of flooding. And if there is less snow in future, winter precipitation will run off faster. There could also be an increase in storm surges.
- ▶ In view of the predicted increase in droughts, mainly in summer, rivers and streams could in future carry less water. Earlier melting of snow in the Alps will reduce the equalisation of low water in the Rhine and Danube during the summer months. Apart from ecological damage, this can also be expected to cause problems for cooling water supplies and for shipping.
- ▶ The water quality of groundwater and surface water is at risk. Intense rainfall and flooding could flush pesticides, fertilisers, industrial chemicals and pathogens from sewage systems into lakes and rivers.
- ▶ Warming of lakes and rivers causes their oxygen concentration to fall. This means stress for the fauna and flora living in them – in addition to the already low water level. Higher temperatures also make for easier separation of pollutants previously attached to sediments.
- ▶ One cannot rule out the possibility of temporary regional shortages of drinking water. Allowance must also be made for the possibility that the treatment process will become more complicated.

## Managing river basins

The aim of the European Water Framework Directive is to achieve good water quality status in all bodies of water. To this end the Directive requires an integrated management system for river basins which includes not only protection of the water but also its uses – even beyond national boundaries. It is still necessary to investigate whether the existing monitoring programmes of the Water Framework Directive are sufficient to register the effects of climate change on such waters. The European Flood Risk Management Directive is also designed to reduce the risks arising from flooding and high water, and to minimise damage.

In view of the existing uncertainties, those parties in river basins that have to take decisions on management plans, flood control

plans and relevant programmes of measures should select the alternatives that promise good and reliable functioning in the face of a variety of climate change effects, and those that maintain or strengthen the natural adaptive capacity of the rivers. Examples include renaturing water meadows or designating floodwater retention areas. The new Federal Water Act is intended to take an important step in the direction of adaptation. The Act is to include a requirement that a minimum flow rate be guaranteed in rivers and streams. This could also result in temporary restrictions on the abstraction of water.

The federal authorities are supporting research projects designed to optimise implementation of the Water Framework Directive and the Flood Risk Management Directive. The federal level also coordinates the German position

in those international river basins which involve German territory – Danube, Rhine, Oder, Ems, Elbe, Maas and Mosel. Moreover, the federal level assists the Länder through the joint task for “the Improvement of Agricultural Structures and Coastal Protection” (GAK), so that they can implement measures on the coast and inland. In addition, the Federal Government is providing an extra €380 million assistance over the period 2009 to 2025 for coastal protection measures made necessary by climate change.

## Adapting infrastructure

What appropriate sewage systems, water storage facilities and drinking water treatment systems will look like in future depends on numerous factors. In addition to climate change, it is also necessary to take account of population development or the uses to which land is put. The aim must be to avoid supply shortages during periods of drought, infestation of water with germs, or situations where intense rainfall causes combined sewer systems carrying domestic wastewater and runoff from sealed surfaces to overflow. To prevent such situations, the draft of the new Federal Water Act provides that in future rainwater must soak away locally, be used for irrigation, or be discharged into a body of water by means of drains kept separate from wastewater sewers. Frequently reservoirs and retention basins are used not only for



storing drinking water, but for generating power as well. Also they can be used to regulate downstream water levels, making it possible to smooth out low and high water situations. To ensure that all this remains possible even during times of climate change, reservoirs must be operated in keeping with the necessary time and space requirements.

### Making efficient use of water

All in all, there will continue to be enough water in Germany. In some districts, however, periods may occur where there is not sufficient groundwater or surface water to satisfy all users simultaneously. In such cases it may make sense to ensure better coordination of demand. Basically, businesses and power plants should examine their production and cooling processes to see whether it is possible to use technologies that use water efficiently or whether, for example, rainwater can be used for certain stages of industrial production. In the agricultural sector too, methods have long existed for low-loss irrigation. It is also possible to use purified and microbiologically safe wastewater for watering fields.

### Supporting precautions against floods

It is not possible to prevent intense rainfall, nor to predict precisely where and when it will occur. One street may be affected, the next street may remain completely dry. It is therefore important to clarify in advance what is the best course of action for people to take in the case of sudden flooding and what precautions they can take. The Federal Government can provide the various actors and the public with general information. Ideally, however, it is the cities and muni-



icipalities which identify where specific risks exist. And it is they who inform the public and companies about what precautions they can take to help reduce these risks, and what they should do in the event of intense rainfall. In addition, provisions in bylaws may require the installation of non-return valves for building connections. It may also be necessary to modify sewage systems to prevent flooding.

### Protecting the seas at international level

The presence of the greenhouse gas carbon dioxide in the atmosphere is one reason why the seas are growing warmer and becoming more acid, and why sea level is rising. As a result, ecosystems are changing and many species are being affected. Thus all measures designed to reduce greenhouse gas emissions also serve the interests of marine protection. Another reason why they are particularly necessary is that the marine ecosystems are already suffering severe stress due to fishing and substance inputs. Here, too, there is interaction between European and national activities: the European Marine Strategy Framework Directive entered into force in July 2008.

In October 2008 Germany gave specific form to the European Marine Strategy through a National Strategy for Sustainable Use and Protection of the Seas. The central concern here is to integrate all policy sectors which adversely affect the biological diversity of the seas in any way.

At an international level, Germany has for years been playing an active part in the international cooperation for the protection of the North Atlantic (OSPAR) and the Baltic Sea (HELCOM) and making efforts to take account of climate change in marine protection policy. The Federal Government is urging the establishment of well managed and sufficiently large protected areas. By protecting animals and plants from harmful activities, such areas give them a better chance of survival, although the impacts of climate change are otherwise just as high here. In the context of HELCOM und OSPAR, the Federal Government and the Länder have already nominated several regions that will form part of the network of well managed marine protected areas, as decided at the World Summit on Sustainable Development in Johannesburg in 2002. These refuge areas are to be established by 2010.

## Observing the soil

To identify changes in the soil, one has to take regular measurements. Data series lasting decades are needed to document climate change effects. Monitoring of this kind is also needed for reviewing progress.

Soil quality has been determined for many years – for example by the “Forest Soil Condition Survey” (BZE II) or the soil fertility appraisal. The findings of these surveys provide important basic information when it comes to investigating what effect a particular climate has on the soil and what adaptation measures make sense. However, the various monitoring systems are not very well networked as yet and the data are not always comparable. The federal and Länder authorities should take joint steps to ensure that this situation changes.

Further targeted research is needed here. To permit made-to-measure regional solutions, scientists need to develop process-oriented models that reveal the interactions between climate changes, land use and soils (see “Making sustainable use of land”, p. 54).



## Soil

How soils develop and what grows in them depends to a large extent on the climate. Climate change could bring an increase in intense rainfall, and temperatures are rising. And if the country is swept by severe storms, this not only influences the nutrient and water cycles, but also has an impact on the millions of micro-organisms that are to be found in every handful of soil – and hence on humus formation, carbon sequestration and erosion. If the land and the soil are used in a site-appropriate way, this can limit the negative effects of climate change. The Federal Ministry of Education and Research has therefore established a new key assistance area: “Sustainable Land Management”.

Agriculture, forestry and water management, nature conservation and spatial planning all have a considerable influence on how soil is used and what it is like as a result. There is a need for suitable data for developing appropriate measures for adapting to climate change.

To prevent conflicts between different users, the Federal Government and the Länder are discussing protection targets and adaptation strategies and involving representatives of agriculture, forestry and water management and also nature conservation and atmospheric and climate research in their work. The aim is to develop optimised solutions that take adequate account of all interests.



## Biological diversity

Climate change has already brought about changes in biological diversity (see Glossary - Biological diversity) or biodiversity in recent years: sardines now live in the North Sea, flocks of birds and shoals of fish are changing their migration times and destinations. Some species are spreading, others are growing rarer or disappearing – and this in turn has repercussions on others. In short: The many and various interdependencies in ecosystems are changing.

Scientists estimate that as a result of climate change up to 30 percent of the animal and plant species currently living in Germany will die out in the decades ahead. At the

same time, naturally invading or artificially introduced species will spread.

Adverse consequences can be expected, especially for many plants and animals in mountain and coastal regions: species that already live high up cannot simply move even higher. Permanent flooding and erosion present threats to the tidal flats of the Wadden Sea. And the picture is also gloomy for species which have specialised in wetlands or localised niches or which have only limited adaptive capacity.

As well as the immediate effects of climate change, there will be changes in land use – and that in turn will have a great impact on habitats. New dykes, expansion of

farmland for growing renewable raw materials, and the construction of transport routes compete with nature conservation areas for scarce land. It will be important here for the Federal Government, and also governmental actors such as the Länder and local authorities and non-governmental actors, to systematically pursue the objectives of the National Strategy on Biological Diversity and of the Federal Nature Conservation Act. In addition, there are numerous pieces of national and international legislation designed to reduce the amounts of pollutants and nutrients entering the ecosystems, because many plant and animal species cannot cope with them.

## Seeking synergies

Efforts should be made to achieve synergies – in other words to take advantage of the fact that different factors can work together and that one measure may have desirable effects in several areas. The federal and Länder authorities should therefore investigate where mutually supportive interaction between nature conservation, climate protection and climate adaptation can be used to maintain biological diversity. For example, wetlands or bogs not only store carbon dioxide (CO<sub>2</sub>), but also serve as flood buffers in the event of intense rainfall. This is the direction pursued by the National Strategy on Biological Diversity and the National Sustainability Strategy, and also by the plans of the Commission of the European Union (EU) and the EU Parliament to stop the loss of biological diversity by 2010. Furthermore, the Federal Ministry of Food, Agriculture and Consumer Protection has proposed concrete measures for preserving and making sustainable use of agro-biodiversity, i.e. biological diversity in the agricultural sector.

## Connecting habitats

Many species need sufficient space if they are to survive successfully in the long term. When space is in short supply, genetic diversity within the species declines, because the community of a species can only be small and no fresh

genes are added. On the other hand, plants and animals need somewhere else to go if conditions within a region deteriorate. Connecting the habitats of a species, i.e. biotopes, therefore helps natural systems to adapt and grow stronger. Establishing such networks is the responsibility of the Länder. Here they should cooperate closely with actors at both local and EU level.

However, the situation is still that new areas are being built on and that natural connections between biotopes are being cut off. This is an area where settlement, infrastructure and transport planning need to take a more circumspect approach. A research project is currently underway which in 2009 is to draw up a concept for taking better account of biotope networking in the planning of supra-regional roads. A joint working

group of the Federal Environment Ministry and the Federal Ministry of Transport, Building and Urban Affairs is already looking into how this can be implemented. There are also plans for closer cooperation with neighbouring states on this issue.

## Further developing protected areas

The federal and Länder authorities should analyse how the existing system of protected areas can be adapted to future requirements arising from climate change. The Natura 2000 system of protected areas already offers refuge and adaptation zones on land and at sea, and also areas of non-use. It thus makes an important contribution to mitigating the adverse effects of climate change on biological diversity.



## Supporting affected species

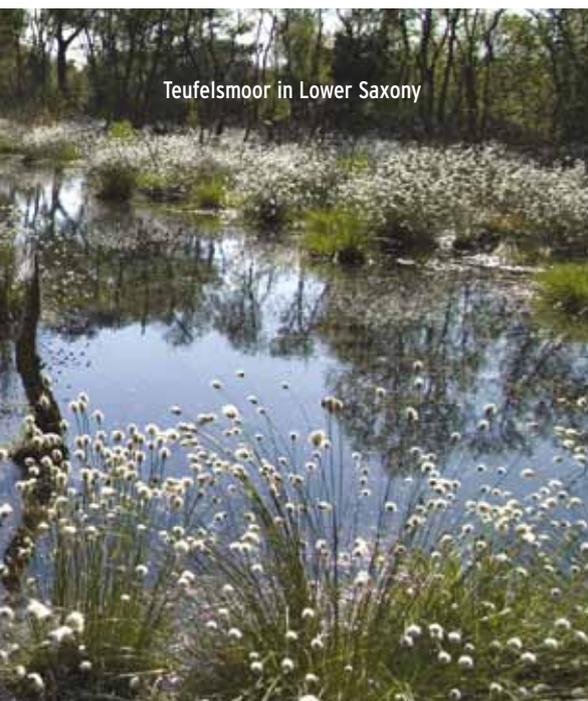
What does climate change mean for seals or for bogland communities? The Federal Government and the Länder should join forces with research institutions and associations to document the effects of both climate change and adaptation measures on species and biotopes. This can be taken as a reliable basis for deciding what can and must be done. It will then be necessary to draw up precautionary programmes. Such data are also needed by anyone who has to assess encroachments and develop compensatory measures.

In the case of species and biotopes that are at great risk from climate change, efforts should be made to reduce other risk factors as far as possible. There is a backlog of demand for species protection pro-



grammes for the seas. Attention should also be focused on coastal areas at risk of flooding and estuary regions. How and where can species find alternative habitats – and how can we

help them? Here there is a need for joint strategies for the development of nature conservation and coastal protection, in order to create and protect alternative options for plants and animals.



Teufelsmoor in Lower Saxony

## Example of wetlands

If summers become drier and temperatures throughout the year show an increase, wetland communities are faced with the problem of survival – a real challenge. There are already state assistance programmes to alleviate the stresses. They seek to regenerate wetlands, stabilise water conditions in bog areas, and to ensure that there is less draining of pasture. Furthermore, links between lakes are to be preserved or restored and the structural diversity of waters is to be promoted – for example by means of different bank types, materials and bank plants. Regular flooding and dry periods are important for flood meadows.

There is a need to take more such measures. To this end, authorities for nature conservation, agriculture and water management should cooperate closely and involve land users as well.

## Taking a coordinated approach to invasive species

The Federal Government and the Länder should agree on a joint approach to invasive non-native species. Because problems for the native flora and fauna frequently arise when non-native species arrive naturally or are introduced, neighbouring states should give each other timely warning if species occur that have not yet been adequately recorded. Moreover, biotope networks should be designed so that they do not give new arrivals a clear run.

## Nature conservation and renewable energy sources

Biomass can be used to generate environmentally friendly heat and power. But this form of energy generation must not be played off



against nature and species conservation or agro-environmental programmes. Anyone seeking sites to grow renewable raw materials should also take account of the aspect of preserving biotopes.

## Flexible design of landscape planning

Landscape planning should take account of the fact that climate change will give rise to changes in nature and the landscape. Because it is not yet clear what form this will take, the road to the future should support flexible de-

velopment options to permit realignment if needed. Open spaces in built-up areas also deserve more attention. Instruments such as municipal landscape planning should be used to take greater account of the contribution that nature and open spaces make to the local climate in settled areas. This also applies when empty sites are filled and in the internal development of existing settlements.

## Biological diversity in the agricultural sector

The agricultural sector too will take account of climate change by means of appropriate use systems and methods. However, the federal and Länder authorities must take care to ensure that the biological diversity of farmland does not suffer. It also makes sense not to improve agricultural production in isolation, but in harmony with nature conservation, soil protection, water conservation and climate protection.



## Agriculture

Regions which under present conditions are too cool or too wet for agricultural use could profit from gradual warming and longer vegetation periods – by becoming wine-growing regions, for example. By contrast, regions which are already warmer and drier must expect to lose out.

In principle, a higher carbon dioxide (CO<sub>2</sub>) concentration in the air promotes plant growth. However, this fertilising effect must not be overestimated. A more decisive factor for crop yields is whether enough water is available for the plants. Furthermore, extremes of weather, especially during crucial growth phases, could restrict growth, or hail or intense rainfall could cause harvest losses. Other potential problems: the winter hardiness of crops could be reduced, and heat-loving pests could spread.

Livestock farmers too will have to readjust. If temperatures are too high, cows give less milk. Their milk yield starts to fall off at temperatures as low as 20 to 25 degrees Celsius. In addition, new or infectious diseases that thrive at higher winter temperatures could spread. One forerunner of such a development may be the outbreaks of bluetongue in ruminants which have occurred since mid August 2006. The virus originates from South Africa and – contrary to earlier findings – was transmitted by native midges.



### Adaptation to climate change in the agricultural sector

- ▶ Where agricultural and forest landscapes are threatened by drought, water retention and irrigation infrastructures are to be improved as part of the joint federal/Länder task for “the Improvement of Agricultural Structures and Coastal Protection” (GAK).
- ▶ Soil fertility and structure and natural regulatory mechanisms are to be supported by agro-environmental measures.
- ▶ Knowledge about adapted forms of land management and about livestock management, nutrition and health is to be disseminated.
- ▶ Breeding of animal species that do not have many problems with climate change will be supported, as will adapted livestock farming.  
(see [www.agrarministerkonferenz.de/uploads/Ergebnisprotokoll\\_AMK\\_0b0.pdf](http://www.agrarministerkonferenz.de/uploads/Ergebnisprotokoll_AMK_0b0.pdf), TOP 23 – German only)

Innovations in the plant breeding sector should be as robust as possible – well adapted to climate change, with a favourable nutrient balance and resistant to diseases. Other wishes on the list include higher yields and greater genetic diversity.

By growing renewable raw materials, farmers should seize the opportunity to introduce more flexible crop rotation patterns and thereby promote biological diversity on arable land.

To promote genetic diversity, the Federal Government and the Länder should give priority to field projects, but without discontinuing laboratory tests.

Measures in the fields of climate change adaptation, water management, biodiversity conservation and bioenergy generation can also be financed from the European Agricultural Fund for Rural Development (EAFRD) – as decided by the EU ministers of agriculture at their meeting in November 2008 (see [http://ec.europa.eu/agriculture/healthcheck/index\\_en.htm](http://ec.europa.eu/agriculture/healthcheck/index_en.htm)).

## Forestry and forest management

Trees are very long-lived and need many years to develop. The expected climate change, by contrast, is coming very quickly. The speed and scale of climate change threaten to exceed the adaptive capacity of forests. More frequent droughts and summer heat-waves are stress factors for forests – in addition to atmospheric pollutants and nitrogen inputs. Areas particularly hard hit will be eastern and south-western Germany and locations with a generally poor water supply. It is foreseeable that stands which are not very well adapted today will have even greater problems in the future; pests such as bark beetles will be in their element here. Mass outbreaks of nun moths or may-bugs will however become more likely elsewhere as well, and there could be an increase in hitherto insignificant pests.

The effects of climate change will be greater in the mountain forests of the Alps than in the lowlands: the risk of mudslides, floods and rock falls will rise. This will fur-

ther increase the importance of forests for the protection of settlements and infrastructure.

## Promoting robust mixed forests

Site-appropriate mixed forests are considerably more robust than monocultures. They also promise reliable timber yields – even in the face of climate change. In view of this, the 1.3 million forest owners in Germany should think again about the composition of their forests and modify them if necessary. Today the Federal Government and the Länder are already promoting the conversion of monocultures to stable deciduous and mixed stands and a near-natural approach to forest management. In view of long production times and climatic uncertainties, however, it is difficult at this stage to make recommendations about specific tree species.

Here the Länder have the task not only of supporting communication between scientists and foresters, but also of further improving the scientific basis for decisions on climate-appropriate forest conversion. This includes systematic observation, the establishment and operation of experimental plots, site mapping, forest plant breeding and provenance research. Moreover, timber harvesting techniques must be refined and optimised. And finally, there is a need to clarify the uses to which timber can and should be put in the future.



## Fisheries

The coastal areas of the North Sea and Baltic Sea and the adjacent exclusive economic zone are subject to intensive use. Fishermen spread their nets here, ships transport large quantities of goods for the global markets, and wind turbines generate energy. Sand and gravel are also extracted. As well as tourism, all this is of enormous economic importance for the structurally weak coastal regions.

Climate change also affects the traditional fish stocks. On the other hand, sardines, anchovies and red mullet have migrated into the North Sea – in the past they were only to be found in more southerly seas. The plankton and bottom-living organisms in the North Sea and Baltic Sea are increasingly being joined by species from other parts of the world, which are largely introduced by shipping traffic.

Climate change is changing the habitats and food bases of the fish populations in the North Sea and Baltic Sea, and also the marine ecosystems of these areas in general. As yet, it is impossible to tell exactly what that means. The new species could turn out to be competitors for food or additional sources of food. In view of the uncertainty about how fish stocks will develop, the Federal Government will urge that decision-making bodies such as the Fisheries Council of the European Union take adequate account of uncertainty margins.

Initially, changing fishing methods is expensive for fishing firms. They have to invest money, while



the new methods are not yet perfected and do not yet bring the full yield. Suitable funding instruments could bring about a consid-

erable increase in willingness to experiment and an improvement in acceptance by the fishing community.

## What can we do to keep the seas alive?

- ▶ For the fishing industry to carry on working in the long term, it is necessary to draw up long-term management and restocking plans. Scientists should keep developments under observation.
- ▶ Incentives should be created to prevent discarding of unwanted catch components. This by-catch is largely thrown overboard again as waste.
- ▶ Catch methods must be improved so that only specific fish are caught in the nets.
- ▶ The uncertainties about the future development of fish stocks call for moderation and ongoing monitoring. At the same time there is a need to establish protected zones. The aim must be to restore the full reproductive capacity of the stocks.
- ▶ Consumers should be made aware of fish that they can buy with a clear conscience. Labels such as certification of compliance with the criteria of the Marine Stewardship Council (MSC) can help here.
- ▶ Fishing personnel should be more closely integrated in tourism so that they can find new sources of income.
- ▶ Environmentally sound aquaculture systems should in particular breed species that feed on plants. That is more sustainable.

## Energy industry

If the climate becomes generally warmer, less heating will be required for buildings. At the same time the need for cooling could increase. These are the important guiding factors for the energy industry. Moreover storms, floods and low water situations could affect power plants, electricity pylons and other energy infrastructure facilities, or temporarily prevent water-borne supplies of raw materials – e.g. coal for power plants. This could result in supply shortages and price increases.

Coal, gas and nuclear power plants all require cooling water. Falling water levels in rivers due to long periods of drought cause problems in this respect: operators have to reduce output, either because there is not enough water available or because the heated water returned to the river would place additional burdens on river ecosystems already severely stressed by heat and drought. This is exacerbated by the fact that the demand for power is higher during hot periods because fans or air-conditioning systems are working at full blast. A better alternative is to insulate roofs and walls and plant shade-giving trees. This will hardly be possible everywhere, though, so



Lignite-fired power plant near Leipzig

heat-induced demand for power will tend to rise.

Climate change can also have far-reaching consequences for systems for generating renewable energy. The scale on which biomass is available depends heavily on the soil and the climatic conditions. The federal and Länder authorities need to bear this in mind in the further expansion of renewable raw materials. Moreover, changes in rainfall have an impact on

hydro power in particular. In view of increasing storms, requirements regarding the strength and stability of solar and wind power systems will increase.

At the same time, however, decentralised generation of energy and a sustainable energy mix including renewable energy sources make for greater security of supply – particularly if generation structures are complementary. The science of energy meteorology investigates the interaction of wind and solar energy use in changing climatic conditions.

In the working group on “Crisis Precautions in the Electricity Industry” set up at the Federal Ministry of Economics and Technology, the Federal Government, Länder and energy industry discuss various emergency scenarios. The industry will have to take the necessary adaptation measures. The Federal Government and the Länder can contribute knowledge and can shape the regulatory framework.

## Energy providers prepare for extreme weather events

- ▶ by putting a large proportion (on a European comparison) of cable sections underground to provide protection against strong winds
- ▶ by providing emergency water connections for power stations in case cooling with river water becomes impossible due to drought
- ▶ by setting up crisis task forces to permit a speedy response to failures in extreme weather situations

## The financial services industry meets on platforms

► In the **Carbon Disclosure Project**, 300 institutional investors inform themselves about climate issues. The major financial services providers in Germany are also involved. On the basis of business surveys they obtain data about company-specific greenhouse gas emissions and can find out what business strategies are available for dealing with the physical risks of climate change.

► The **Munich Climate Insurance Initiative** brings together insurance companies, reinsurance companies, environmental associations and scientists. It is concerned with insurance company strategies for dealing with climate change.

► The “**Financial Forum: Climate Change**” was set up by the Federal Ministry of Education and Research. It is working on the question of how climate protection and adaptation can be advanced by means of research and innovation.

## Financial services industry

The financial services industry operates on an international basis – which means it is also affected by global developments. The worldwide climate changes have direct consequences for the insurance industry: in recent years insurance companies have had to pay out considerably more money for claims. Admittedly the population growth in coastal cities in particular plays a role here, as does a general increase in the value of the assets insured. But this does not alter the causes of the damage. In future the insurance industry will no longer calculate its premiums entirely on the basis of past experience, but will make allowance for the expected effects of climate change. Pension funds and other investors in long-term infrastructure projects are also beginning to reassess the risks.

But climate change does not threaten solely physical facilities and buildings in which the financial sector has invested. Policymakers and society are also changing the framework conditions for investments to take account of climate change. While this involves risks for the financial services industry, it also offers substantial opportunities. Here banks and insurance companies are called upon to take an active management approach to preparing for both.

It is foreseeable that there will be an increase in demand for property insurance covering damage due to natural hazards. The insur-

ance industry can inform and educate clients and authorities, and write policies that encourage people to take precautions against hazards. In addition to the insurance companies' usual instruments and business models, new financial market products will be developed for specific risks to enable businesses or countries to cover climate risks on the capital market. These include weather derivatives, catastrophe bonds or other special bonds.

### What the state can do

The state supervisory authorities at federal and Länder level must take increasing care to ensure that the risk models used are sufficiently robust to guarantee the financial stability of the insurance companies and banks. One current special problem lies in the fact that the international rules imposed by the Basel-II Accord prohibit banks from using data other than historical data as a basis for equity capital and

risk management. As a result, innovative methods such as Bayesian risk management are only of limited practical use at present. The Federal Government intends to change this situation and will therefore put this topic on the international agenda.

If the private sector is unwilling to cover certain risks for economic reasons, the state may have to supplement the products offered by the financial services industry. This could be necessary if the persons concerned could not afford the necessary premiums or if the size of the potential losses was too great. For example, it is conceivable that a compulsory elementary loss policy for all citizens might be introduced, or a state fund solution. In any case, however, this can only be the last resort. Such approaches have been pursued since the Oder floods in 1997. The Federal Government – in consultation with the Länder – intends to launch a new initiative here.

## Transport

Extreme weather situations involving snow, ice, fog, hail, heat-waves, storms, intense rainfall, floods, low river levels or heavy seas can interfere with road, rail, water and air transport.

For example, heavy rain means poorer visibility and a consequent decline in road safety – resulting in more accidents. Cloudbursts may also undermine roads and railways or cause landslides.

High temperatures not only reduce human powers of concentration **on the roads**. Prolonged heat also softens the asphalt, resulting in tyre ruts. Modified construction materials can help here. Intense rainfall can be drained away by providing roads with larger-capacity drainage systems. The Federal Ministry of Transport, Building and Urban Affairs will review and adapt the relevant provisions.

Higher mean temperatures in winter could prove an advantage for the infrastructure: frost damage to roads and bridges will be less frequent. There could also be a reduction in the number of accidents due to snow and ice.

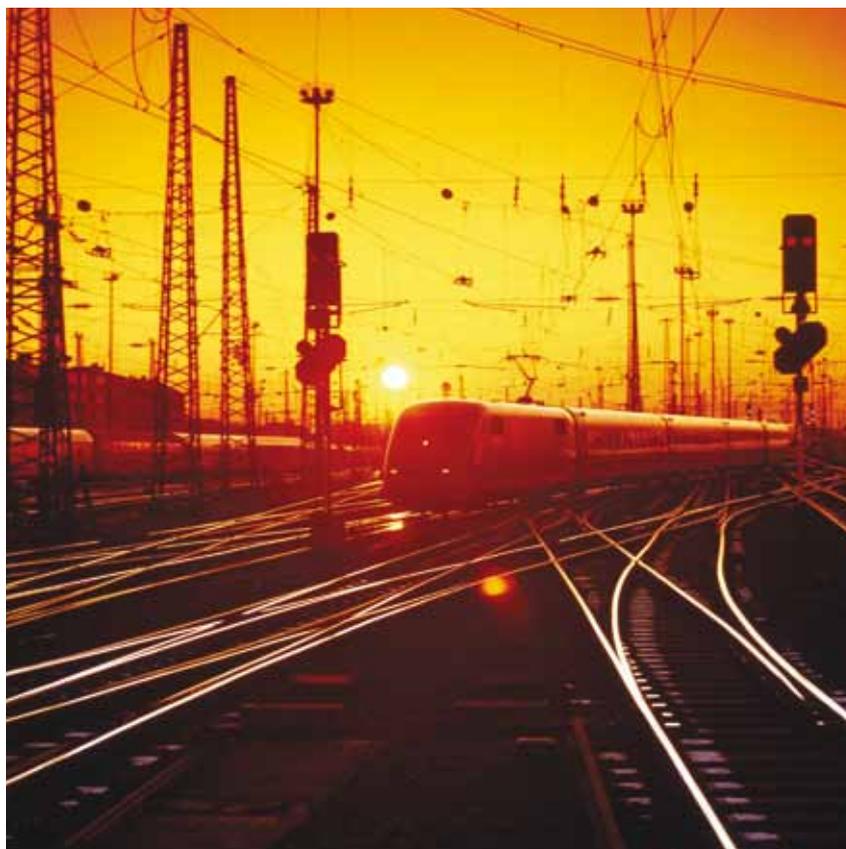
In the **rail traffic sector**, the effects of climate change will relate primarily to the infrastructure. Storms could damage signals and power supply lines, and trees could fall onto the tracks. Fires on adjacent slopes could become more common if conditions are hotter and drier. To combat dam-

age it could be necessary to adapt land use along railway systems to the climatic situation. In addition, floods could submerge railway facilities.

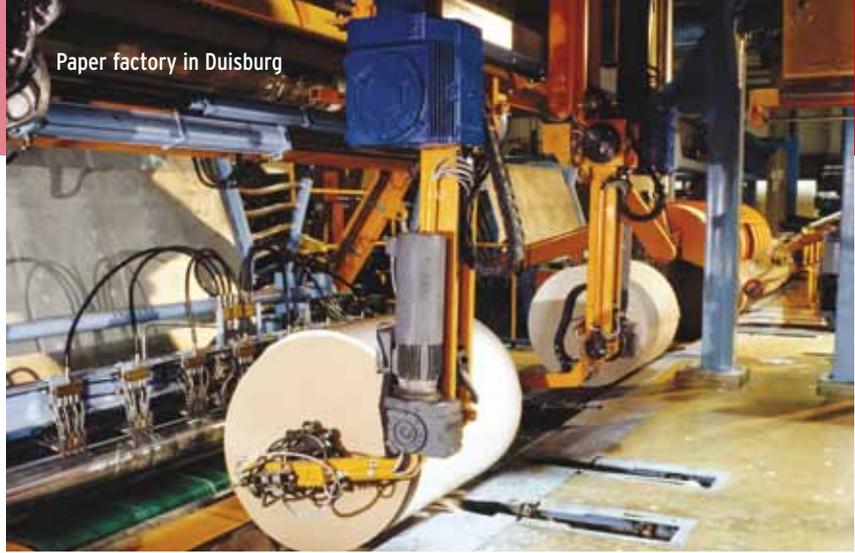
Research is necessary to obtain a clearer picture of whether high temperatures create a need for new maintenance techniques. One particular issue is whether internal tension stresses in continuously welded rails could rise to dangerous levels.

**Air traffic** will only be marginally affected by possible climate changes – according to the latest analyses. It may nevertheless be necessary to adapt operations at airports and in the air traffic control sector to cope with more fre-

quent extreme weather situations. The effects of climate change on **marine transport** in the North Sea and Baltic Sea have to be considered not only in regional terms, but also on a larger scale, since the ports have worldwide links via marine transport routes. The predicted rise in sea level has a direct impact on seaports. If currents change, water levels rise or fall, waves grow higher, wind speeds increase and icing conditions change – these all have impacts on navigation. The effects that climate change will have on sea routes remain to be investigated. New sea routes to Arctic regions might open up. There is a need for timely investigation and coordination of the best ways of using them.



Paper factory in Duisburg



In addition it could be necessary to adapt forecast and warning services, risk management and rescue services, infrastructure and marine technology to take account of changed conditions.

For **inland waterways**, water levels are of particular importance. They vary according to when and how much it rains or snows in the catchment area. Water levels in German rivers have always displayed a great deal of seasonal variation. Climate change could cause these fluctuations to increase.

A distinction has to be made between free-flowing rivers and backed-up waterways, which include canals. The crucial factor for the latter is long-term changes in water supply, because in the short and medium term the water level can be kept stable by means of locks and weirs. By contrast, free-flowing rivers are of little or no use as inland waterways during periods of extreme low or high water. Changes in discharge patterns have impacts on the river bed and the river/meadow system, for example if they result in shifting sediments. Water quality can also suffer. In order to develop reliable adaptation measures, the Federal Ministry of Transport, Building and Urban Affairs launched the research programme “KLI-WAS” in 2008.

## Trade and industry

Adaptation to climate change also offers great opportunities for innovative companies and exporters of environmental technology. For example, many companies in Germany have developed and implemented water-saving and waste-water-free processes since the 1980s. These have made the water-intensive chemical, paper and textile industries less dependent on water as a raw material and coolant. If dry periods increase, this could have even greater economic advantages.

Changes in external temperatures have an impact on the energy balance of operations that need heat and cold. In many cases a deterioration in the figures can be prevented by means of technical in-

novations or thermal insulation. This creates new possibilities for the building industry – and opens up opportunities for innovation and employment.

However, climate change also means considerable risks for many businesses. Storms, intense rainfall and floods could damage or destroy industrial facilities or release hazardous substances. This calls for precautions by plant safety managers. Turbulent weather could also have an impact on operations, e.g. in the event of personnel or materials failing to reach the factory. If electricity, telecommunications or water supplies are interrupted by severe weather conditions, this could also result in operations coming to a standstill elsewhere. All this can prove very expensive.

## The Commission on Process Safety (KAS) has made the following proposals:

- ▶ Design plants covered by the major accident regulations to withstand more frequent and more severe storms
- ▶ Protect plants from extreme rainfall and floods  
Make emergency plans and risk prevention plans
- ▶ Improve safety management
- ▶ Take account of the requirements of climate change when drafting legal and technical regulations.



Artificial snow slope near Munich

Furthermore, extremes of weather are a threat to agricultural production yields (see “Agriculture”, p. 35) and may also indirectly affect operations that process food or renewable raw materials. It will therefore be advisable not to rely entirely on suppliers from a single region. As a basic principle, businesses should bear in mind in their purchasing and stock policies that roads, railways or waterways may be blocked from time to time.

Anyone selecting a new industrial location should take account of the effects of climate change and should, for example, consider whether there is a possibility that the site might soon be under water as a result of rising sea levels. This applies not only to company locations in Germany, but also to subsidiaries and suppliers elsewhere in the world. Countries where the effects are limited or which pursue a targeted and effective adaptation policy have an advantage here.

Together with the Länder and industrial associations, the Federal Government will conduct more detailed research into the many and varied impacts on trade and industry.

## Tourism industry

Where people go for their holidays depends to a large extent on the weather they can expect there. This means that global climate change could bring about major changes in travel patterns – with massive consequences for the economy, infrastructure and labour markets in the countries affected. Moreover, the tourism industry will also be affected by extreme weather events.

Climate change has direct impacts on the economically important winter sports sector. For over 50 years many places have had less snow. In future, skiing in the Alps will only be possible at heights above 1,500 metres, and hence in regions that are especially sensitive from an ecological point of

view. In central upland areas the range will be around 800 to 1,000 metres. Even snow cannons will not be any help here: temperatures at lower altitudes will be too high for them.

At the same time, changes in climatic conditions open up new opportunities for tourism: existing off seasons could become more popular. Regional shifts can also be expected. The Potsdam Institute for Climate Impact Research (PIK) expects that 25 to 30 percent more tourists could come to Germany. The North Sea and Baltic Sea will become more attractive, while the Mediterranean could often be a source of heat stress at 40 degrees Celsius or more. Even in Germany it could at times be too hot for certain holiday activities.

## Investigating holiday regions

The research project “Climate trends and sustainable tourism development in coastal and central upland regions” (KUNTIKUM) is designed to help the tourism industry readjust and adapt to climate change. To this end the Federal Government has commissioned the Institute for Environmental Communication at the University of Lüneburg to investigate the examples of the North Sea coast and the Black Forest. The aim is to transfer experience to other regions as well, and to establish an information and communication platform which also includes a further training module.

## 3.2 Regional policy, regional planning and civil protection

### Regional planning

The purpose of regional or spatial plans is to resolve conflicts about different claims on space, which usually means they are a decision taken for generations. From now on, spatial planning must not only take account of current demands when designing such spatial precautionary concepts, but must also consider and include climate protection and adaptation. This is possible with the present legal and planning instruments, but it makes for increased competition – because climate protection and adaptation measures also need space.

The best location for wind power or photovoltaic systems, and the extent to which this is compatible with the interests of residents, farmers, tourists and wild animals, is also a question of spatial planning and regional policy. One of the issues in cities will be to keep open fresh air channels to prevent overheating in summer.

### Precautions against extreme weather situations

If the probability of floods increases, there are two precautionary measures in particular that are critical: river banks and flood areas should not be built on, and flood discharge should be prevented or regulated. To ensure that there is more space for water so that it causes less damage, as many flood areas as possible should be designated by the year 2020.

The basic guide for spatial planning should be the risk of the type of extreme flooding which occurs statistically on average every 200 years.

New buildings, car parks and roads seal the land surface and further increase the probability of flooding. By contrast, the situation is eased if the rain can soak away where it falls. Improved drainage through decentralised rainwater soak-away facilities, renaturing of rivers and lakes, reforestation and adapted agriculture promote localised retention of water and increase groundwater recharge at the same time.

Dykes must continue to afford coasts and islands the best possible protection against storm surges.

It is also important to develop new types of safety measures that still function even after dykes are breached.

In the Alps there will be an increase in mudslides, rock falls and soil erosion if intense rainfall and storms become more common. Here regional policy must take precautions to keep high-risk areas free from building and traffic.

Densely settled urban regions can heat up like an oven in summer – which is not only unpleasant for the residents, but also unhealthy. Connections with forests and other areas where the air is cooler can provide a change of air. Keeping these airways or climate channels open is an important task of regional policy, regional planning and urban development.



Dyke on the North Sea island Pellworm



## The landscape is changing

If climatic factors mean a reduction in the quantity of groundwater formed, this increasingly scarce resource must be safeguarded by regional policy and other means. It is also important that such planning should bring about appropriately adapted use.

If the sea level rises, so does the water table. Moreover, coasts will erode faster than in the past. Regional policy and coastal protection must therefore include climate change as an important factor in the development of coastal landscapes.

If holidaymakers take different decisions in future, e.g. more of them travel to the North Sea or Baltic Sea, or if tourists in mountain regions pursue different activities than in the past, the infrastructure must be geared to this. New climate-appropriate concepts could be supported by model regional policy projects.

Animals too will follow different paths, and there will be shifts in the locations of plant species. Regional policy - and especially landscape planning - can help them by safeguarding priority areas for nature conservation and promoting ecological networks.

## Protecting the population

Civil protection is a broad field. It begins with precautionary measures, in other words to safeguard the basis for life, and offers help

if a disaster has already occurred. It is only recently that the responsible bodies have started to take a closer look at the issue of climate change and what it means for civil protection. One fact is clear: If the future holds a greater threat of severe storms, floods or drought-induced forest fires, then crisis and emergency management must adapt accordingly. At the same time it is important to help the public to protect themselves better.

Special attention should be paid to energy and water supply, transport and telecommunications and information technology, because they have the function of “lifelines of society”. Since they are mutually dependent, they are particularly vulnerable. If the power supply fails, waterworks and computers cease to function as well. And without telecommunications, it is difficult to coordinate other supply facilities.

Protecting critical infrastructures (see Glossary - Critical infrastructures) must therefore be given high priority, as their failure can result in considerable problems for public safety or other dramatic consequences. On the other hand only about 20 percent of these infrastructures are owned by the state. The rest are owned or operated by private-sector companies – which are thus responsible for their trouble-free operation. However, because the state has a duty to ensure reliable supplies to the public in emergency situations,

partnership-based cooperation between the Federal Government, the Länder and private enterprise is indispensable. The Federal Ministry of the Interior has therefore developed guidelines. Their aim is to prevent the failure of facilities as far as possible, for example by ensuring better protection for buildings or power lines. If problems arise, proper functioning is to be restored as soon as possible. In addition, emergency and evacuation plans, warning systems and information facilities are important to ensure the best possible preparation for disaster situations.

At federal level, the working group on “Climate Change and Civil Protection” has been in existence since 2007. It includes experts from the Federal Environment Agency, the German Weather Service, the Federal Agency for Technical Relief (THW) and the Federal Office of Civil Protection and Disaster Assistance (BBK). The federal and Länder authorities are continuing their joint work on improving deployment tactics and technical equipment so that they are prepared for the impacts of climate change.

The numerous natural disasters of recent years have shown the shortcomings of civil protection in Germany: Authorities and emergency personnel need to cooperate more effectively, and information and alert channels need to be improved. In addition, the population needs timely, clear and effective warnings and information.

### 3.3 Regional diversity

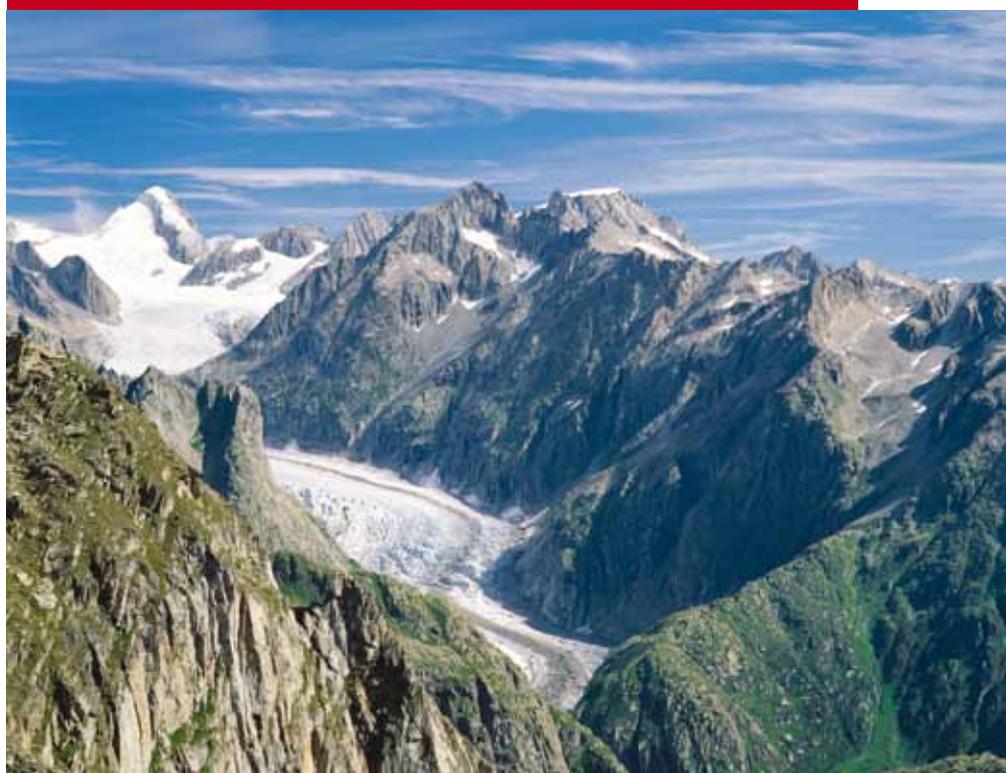
The impacts of climate change in mountain regions are different from those in the lowlands or on the coast. There are also differences in the vulnerability of locations – depending on land use, local natural conditions and existing capacity to adapt. Consequently the regional adaptation strategies must also differ. A detailed geographical approach should include not only the expected effects of climate change, but also other regional factors. The aim is an integrated cross-sectoral concept that seeks to reconcile the various usage interests. This section takes a closer look at the vulnerability (see Glossary - Vulnerability) of certain regions.

#### The Alps are particularly vulnerable

The Alpine region is doubly affected by climate change. For one thing, temperatures here have already risen twice as fast as the global average – and all climate models predict that this trend will continue and a further rise of 3 to 4.5 degrees Celsius will take place by the year 2100. For another, climate change has a particularly strong impact on such a sensitive ecosystem as the Alps.

## The threats to the Alps

- ▶ The zones in which plants and animals live will shift to higher altitudes. If they have nowhere else to go, they will die out.
- ▶ Mountain forests will suffer – thereby providing less protection against avalanches, mudslides and rock falls.
- ▶ The glaciers are retreating. This will also change conditions in the rivers and lakes that are fed by glaciers.
- ▶ Many winter sports resorts at lower altitudes will lose their main source of income, because they can no longer offer reliable snow. Within the Alps, the areas in Germany will be hardest hit.



Many plant and animal species occur only in the Alps and are highly specialised. If their environment changes, this can have fatal consequences for many of them. Other species that are dependent on them will also die off. It is clear that it is already too late to prevent certain effects of climate change in the Alps. Here the focus must be on adaptation.

#### The Alps as a model region

The eight signatory states to the Alpine Convention have put the issue of climate change right at the top of their agenda. If they succeed in implementing practical strategies for sustainable development, the Alps could become a model showing how a badly affected region can adapt to climate change and cooperate closely across national borders.



## Drier and hotter in the south and east

Conditions in large areas of eastern Germany, on the north-east German plain and in the south-east German basin are already relatively dry. If there is even less rain in the summer and even more water evaporates because of higher temperatures, this could result in harvest losses. In addition, less groundwater will be available and streams may dry out. Moreover, the high summer temperatures predicted for the Lausitz area (the south-eastern corner of eastern Germany) in particular are likely to cause increasing health problems.

The weather observation data for south-western Germany for the past 100 years show that temperatures here have risen faster than the average. The trend can be expected to continue, and farmers, foresters and forest owners will have to adapt to it. Models indicate that heat-waves will become longer and more frequent in the Rhine rift valley – a special challenge for the health sector. At the same time there will probably be more rain in the winter: rivers and streams can therefore be expected to burst their banks more often.

In March 2009 the parties to the Alpine Convention approved an action plan. It is partly concerned with reducing greenhouse gases in the fields of transport, tourism and energy production. But the plan also provides for adaptation strategies. The spectrum of issues is broad and ranges from protection of biological diversity, through protective forests and the water regime, to sustainable tourism. The intention is to designate pan-Alpine danger zones and use them as a basis for regional planning. Protected areas are also to be networked across the Alps to make it easier for plants and animals to migrate and seek refuge. There are also three projects with European assistance that are helping to support the Alpine-specific adaptation measures; some of their findings are already available. One of them is ECONNECT, which promotes an alliance of ecological networks in the Alps. This network is supported by the Federal Environment Ministry.

## Rising sea levels are a long-term threat to the coasts

By the end of the century, the air at the North Sea and Baltic Sea coast will probably not be significantly warmer on average than it is at present. But there is evidence to suggest that the fluctuations will increase. It is not yet possible to estimate what changes will take place in the number of frosty days

or warm nights. There will, however, be a tendency for summers to become drier. In the second half of the century the sea level could rise and storm surges could intensify coastal erosion. This would also bring a rise in the concentration of salt in the groundwater. Scientists still disagree about the potential scale of these problems. The Federal Government and the Länder are therefore making efforts to reduce the threat today by means of coastal protection management – as is being done in the General Coastal Protection Plan for Schleswig-Holstein. They are focusing particularly on wetlands and low-lying areas, and on regions where flooding would cause extreme damage. Examples include the port of Hamburg, or offshore wind farms.

## Multiple interests at the coasts

Integrated coastal zone management (ICZM) is an inter-Länder und cross-sectoral concept based on voluntary participation. It is intended to ensure that the claims of industry, society and nature are all catered for and harmonise as well as possible. It includes the development of joint perspectives for the future and timely involvement of all planning and decision sectors. It is clear that ecologically and economically acceptable development of coastal areas will only be possible if the changing boundary conditions are always taken into account. Climate change heads the list of factors. To broaden the knowledge base, the Federal Government is promoting several research projects and having cooperative learning projects investigated.

### 3.4 Climate protection and adaptation – combining the two wherever possible

Those who adapt to climate change should on no account undermine climate protection efforts, but should give preference to measures that are as climate-friendly as possible.

On the other hand, it is not always possible to achieve a meaningful combination of greenhouse gas reduction and adaptation measures: It may even happen that “one man’s meat is another man’s poison”. Where this is foreseeable there is a need for a planning approach that reduces the undesirable effects as much as possible.

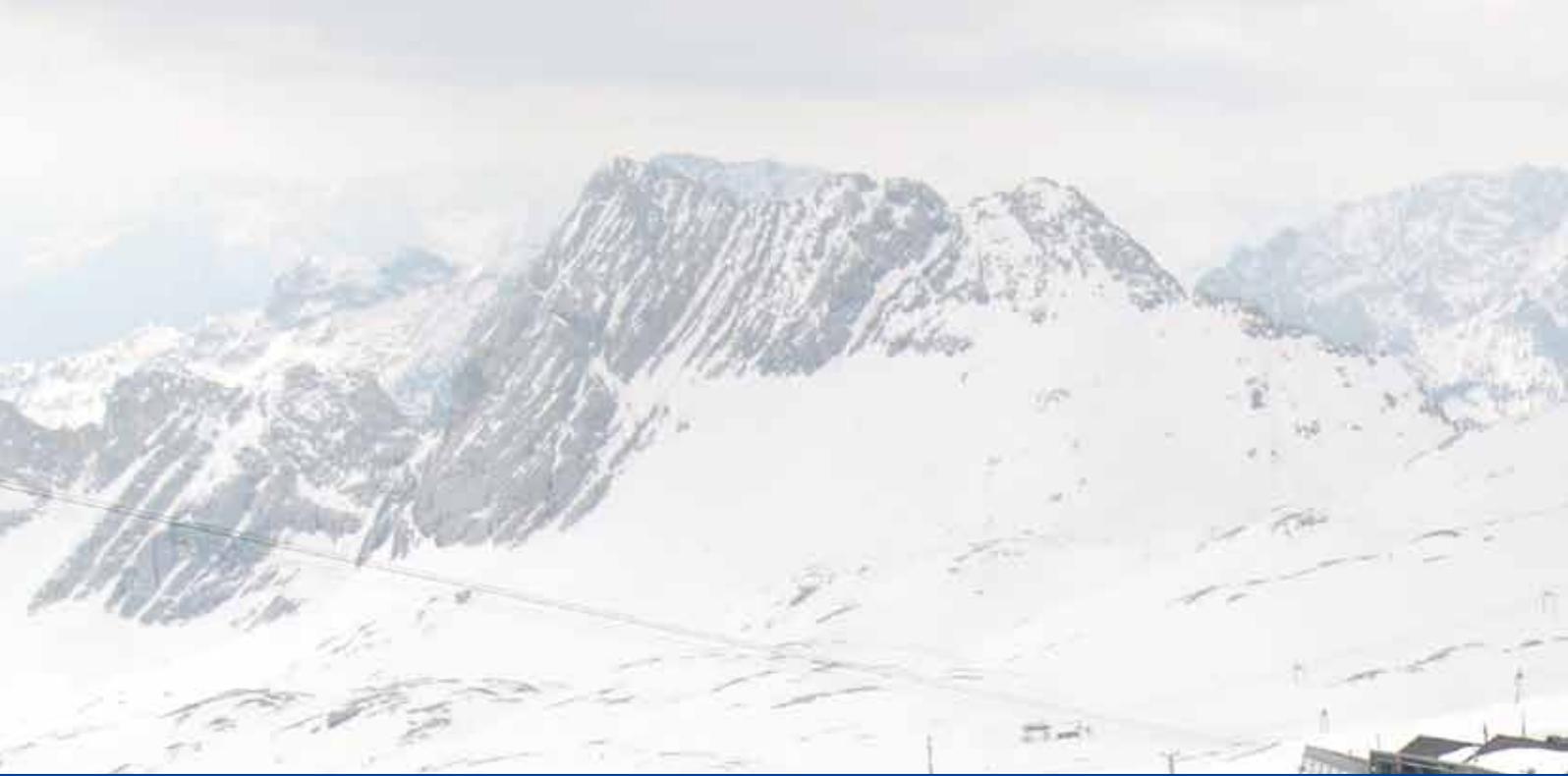
#### Win-win situation

- ▶ People who insulate their buildings need less heating in the winter and enjoy better protection from heat in the summer. They also reduce health stresses due to noise.
- ▶ Agricultural land use appropriate to nature conservation and flood control in flood areas can produce valuable renewable raw materials, for example. It can be robust and economically profitable and in line with flood control.
- ▶ Those who convert their forests from monocultures with only one planted species of tree into a mixed forest stabilise the forest ecosystem. They can also expect reliable timber yields.



#### Where conflicts may occur between climate protection and adaptation

- ▶ Land is needed to grow renewable raw materials, which makes sense from the point of view of climate protection. Land is also needed to set up a biotope network so that animal and plant species can move in response to changed climatic conditions. Both objectives make sense – and they compete with each other.
- ▶ If people in a city live as close together as possible, this reduces energy consumption – and thereby protects the climate. However, dense urban structures can lead to increased heat stress in the summer and call for adaptation measures – partly to avoid wasting too much energy on cooling. There is thus a need for careful design of the remaining open spaces. Insulating buildings, minimising surface sealing and planting shade-giving deciduous trees helps to ensure that life in the city does not become unbearably hot. Planners must always keep an eye on such interactions between climate protection and adaptation to climate change.



# HOW TO DO IT - RESEARCH SUPPORT FOR ADAPTATION





Whereas climate research was previously more concerned with understanding how the climate system works and what can be done to prevent man-made climate change, the science today is also looking into how best to deal with the consequences of such change.

The Federal Government has made strategies for adaptation to climate change a focal point of its High-Tech Strategy for Climate Protection, work on which is headed by the Federal Ministry of Education and Research. The issue of adaptation also enjoys high priority in other federal ministries. For example, the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety is investigating how to minimise the

harmful effects of climate change on water, soils, biological diversity and health. The Federal Ministry of Transport, Building and Urban Affairs is focusing particularly on the consequences for shipping and regional policy. And the Federal Ministry of Food, Agriculture and Consumer Protection is looking into aspects of breeding, forestry, crop growing and livestock farming.

### What influences the climate, and how is it changing?

The interconnections are extremely complex. How the climate develops does not depend solely on the atmosphere. Oceans and

land surfaces are also central factors – and frequently there are complicated interactions. Finding these out is the task of **climate system research**. Only on this basis is it possible to develop scenarios and models for the future – and not until these exist can one start to draw up adaptation strategies.

Only if we understand how the climate system works can we make serious forecasts about what is likely to change – and use them to arrive at specific adaptation measures. Scientists at the research centres of the Max Planck Society (MPG) and the Helmholtz Association, at Leibniz Institutes and universities have long been studying how temperatures, oceans, air and land masses influence the climate. Early 2009 will see the installation of a high-performance computer at the German Climate Computing Centre (DKRZ) in Hamburg which can process a wide range of different data and work out sound and detailed climate models. This will make it possible to forecast not only worldwide, but also regional developments. Since 2005 the “Adaptation Service Group” at the Max Planck Institute of Meteorology in Hamburg has been working on a standard basis for methods and data relating to climate change. The researchers aim to produce practical results and advise people who need to understand the climate models for their decisions.



Return of the flower queens: orchids such as the bee orchid are spreading again in Germany



Climate model forecasts to date have related to periods that lie well in the future. However, to plan precautionary measures and economically relevant investment projects with their planning, financing and implementation periods there is a need for more detailed information about climate developments in the next ten years, i.e. medium-term forecasts. In future this ten-year period is to be covered by weather and climate scenarios. The Federal Ministry of Education and Research intends to promote the development of such “medium-term climate forecasts”.

### What is particularly at risk, and where?

**Climate impact research** investigates what impact climate changes have on other natural systems. How does the water cycle change, how do plants and animals react? Impacts on human living conditions are also a central focus of climate impact research: What do longer periods of drought mean for farmers, and what is the future situation regarding snow in specific holiday regions?

Various institutes and universities in Germany are working to answer these questions. For example, social and natural scientists at the Potsdam Institute for Climate Impact Research (PIK) are elaborating system analyses, scenarios and computer simulations. On this basis politicians, businesspeople and civil society can make sound decisions about climate protection and adaptation strat-

egies. The German Weather Service (DWD) also provides important information that can be used to assess the effects of climate change on the urban climate, the health sector and the agricultural and water management sectors.

To enable federal, Länder and local authorities to take a systematic approach to the adaptation issue, they need a common basis of methods, data and information about climate change, the expected consequences and the effects already observed. They also need indicators to identify feedback and interactions. On this basis it is possible to make a systematic investigation of specific questions. What impact does climate change have on a specific industry, who will be particularly hard hit in a given region, or what does the construction of a dyke mean for biological diversity – and what other sectors does it affect in turn?

## Initial research findings

- ▶ The Federal Environment Agency's "Vulnerability Study" dating from 2005 (Zebisch et al 2005), which provided a first combined overview of climate change impacts and vulnerability estimates in a nationwide overall study covering a comprehensive range of methods.
- ▶ Results of the DEKLIM research programme (Federal Ministry of Education and Research), including data on the vulnerability of the German coastal region.
- ▶ The status report by the Federal Agricultural Research Centre on climate change effects and adaptation measures for the agricultural sector in Germany (2007).
- ▶ The Federal Ministry of Transport, Building and Urban Affairs has published a brochure on "Navigation and Waterways in Germany – Meeting the Challenges of Climate Change – A Review" (see [www.bmvbs.de/en/dokumente/-,1872.1046457/Artikel/dokument.htm](http://www.bmvbs.de/en/dokumente/-,1872.1046457/Artikel/dokument.htm)). The gaps in research will now be filled and adaptation options developed.
- ▶ The Federal Ministry of Transport, Building and Urban Affairs will run model projects concerned with how regional development is changing in the light of climate change. These will also investigate how one can arrive at meaningful results in spite of numerous uncertainty factors. The preliminary study to identify different climate change region types will run until the end of 2009.
- ▶ The Federal Ministry of Education and Research plays an active part in the research network CIRCLE, which brings together institutions from 19 European Union countries that fund research into climate change effects and adaptation.

The Federal Government will have proposals drawn up on methods of assessing vulnerability. Indicator systems are also to be developed. Technical support for this is provided by a concept study commissioned by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, which is expected to yield findings from 2009 onwards. The Federal Ministry of Education and Research is also constantly at work on this issue.

### Investigating adaptation in individual regions and research in economic sectors

Adapting to climate change primarily means reducing the negative aspects of climate change for man and the environment and preparing oneself in such a way that prosperity, quality of life and prospects for the future suffer as



Wine growing in north-east Germany - in Brandenburg



Weather station on the North Sea island Amrum

little as possible. The aim of **adaptation research** is to develop strategies and measures that can be used to fit regions or economic sectors for life and economic activity under the conditions of climate change. On a regional perspective the aim is to take account of climate change effects in regional planning and decision processes, create regional networks, and develop and test technologies, methods and concepts for adaptation in the individual regions. The focus of sectoral adaptation research is on specific areas of need, such as food, or value added chains. Another central concern is the social consequences of climate change and how to cushion them.

Sectoral adaptation research is nothing new: for over 20 years the Federal Ministry of Food, Agriculture and Consumer Protection has been investigating what form site-appropriate agricultural production could take under climate change conditions. At the beginning of 2008 a new institute was founded primarily to investigate what climate change means for agriculture and forestry, fisheries, rural areas and bodies of water – and what are the best ways of tackling it from an economic and environmental point of view. Should one grow different crops or make technical changes? What new parasites can be expected – and how does one get them under control?

## Where research is taking place

**Klimazwei** – In this assistance programme the Federal Ministry of Education and Research is pursuing the objective of developing practical aids to action. It supports projects designed to reduce greenhouse gas emissions. It also provides assistance totalling €15 million for 19 research networks that are developing adaptation measures (see [www.klimazwei.de](http://www.klimazwei.de)).

**KLIMZUG** – The Federal Ministry of Education and Research has established the key assistance area KLIMZUG: “Managing climate change in the regions for the future”. It is intended to help regions to include the expected extreme weather events in their plans and to make them fit for life under climate change conditions. The regions are to establish networks, share experiences, technologies and strategies and – where possible – jointly take advantage of opportunities. From 2008 to 2013 the Federal Research Ministry is providing €75 million for KLIMZUG (see [www.klimzug.de](http://www.klimzug.de)).

**GLOWA** – The topic of “Global Change and the Hydrological Cycle” is the focus of five major joint projects that have been working together since the year 2000. They are developing a basis for decision on how water as a vital resource can best be managed under changed framework conditions. Within Germany assistance is being provided for the GLOWA projects on the Elbe and Danube.

**KLIWAS** – The Federal Ministry of Transport, Building and Urban Affairs launched the research programme “KLIWAS” in mid 2008: “Impacts of climate change on waterways and shipping – Development of adaptation options”. In addition to transport issues it is also to investigate other aspects of marine, coastal and inland waters. The central issue is the question of what impact falling or rising water levels, extreme high and low water and changes in rainfall and evaporation rates have on shipping. The water management sector will also be able to benefit from the results later. The ministry is also promoting a model project investigating what climate change means for regional policy, regional and urban development and how adaptation could be implemented in practice in this field.



Alder swamp forest on the island Rügen

## Making sustainable use of land

Whether a piece of land is covered by forest, asphalt or fields has an influence on the local climate. The diversity and performance of the organisms encountered here also depend to a large extent on the type of land use. Conversely, the ability to grow crops or enjoy the benefit of other services such as groundwater or fresh air depends heavily on how much and how often it rains or what temperatures prevail. In short: interactions between climate and land use determine the character of the system. Investigating them is increasingly becoming a focus of scientific interest: after all, future ways of using the land depend heavily on this aspect.

On the one hand it is a question of preventing or at least alleviating negative effects of encroachments. On the other, the land surface is both a source of and a sink for greenhouse gases. The latter means, for example, that the greenhouse gas CO<sub>2</sub> can be fixed in forests or bogs.

Because many aspects here are interconnected, researchers can only make progress with integrating, i.e. comprehensive approaches. The Federal Ministry of Education and Research has recently invited tenders for a key assistance area in this field. The aim is to develop strategies, action options and system solutions in model regions particularly affected by climate change.

## Federal Government provides tools for actors

There is no point in constantly re-inventing the wheel. The Federal Government is therefore making available a toolbox that enables actors to find out what climate change has in store for them in their field and what means they have of dealing with it. Check lists are provided to help businesses, organisations and administrative entities.

One example is the joint project of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and the Federal Environment Agency on “Operational and strategic support for the management of climate risks and opportunities”, which has been running since the end of 2008. The project catalogue “Good Practice” is also helpful – it can be seen on the Internet at [www.anpassung.net](http://www.anpassung.net) (German only).

The Federal Government is preparing a geographical information system which will provide risk maps on specific topics.

Suggestions for the development of similar tools already exist in the United Kingdom, for example. The UK Climate Impacts Programme makes the tools “Adaptation Wizard”, “Business Assessment Tool” and “Local Climate Impacts Profile” available free of charge.

### Setting priorities, identifying successes and failures

To arrive at an appropriate assessment of the need for adaptation, it is necessary to take account of the impacts in various sectors. And to identify key areas or action priorities that are widely accepted, there is a need for generally recognised assessment criteria. For example, one could agree that irreversible changes are the most important ones to avoid. Suitable assessment criteria might also include the scale of the expected impacts, the size of the damage, and the question of whether the effects occur immediately or only in the distant future.

To date there are no agreed criteria for Germany. Research is needed here first as a prelude to discussions and decisions.

In many cases climate change will result in economic losses. But countermeasures also cost money. Economic analyses are an impor-

tant basis for weighing up different action options. In addition, it is necessary to calculate the damage that occurs in spite of adaptation measures.

Within the Federal Government’s High-Tech Strategy for Climate Protection there are currently a number of research projects that seek to assess the consequences of climate change for industries, economies, globally interlinked value added chains and the global economy as a whole. They aim to take into account not only the costs, but also the economic benefits for individual industries and economic sectors that arise from the international climate conventions. After all, the demand for climate-friendly technology will show a further marked increase. Are the results

of adaptation what was hoped for and expected? Before a measure is extended or transferred to other regions, its success should be checked. The reactions of residents, businesses and associations can also provide an indication of whether the project can be regarded as “good practice”. Success should be measured in terms of the classic sustainability triad: What does the measure – or its absence – mean for ecological, economic and social aspects?

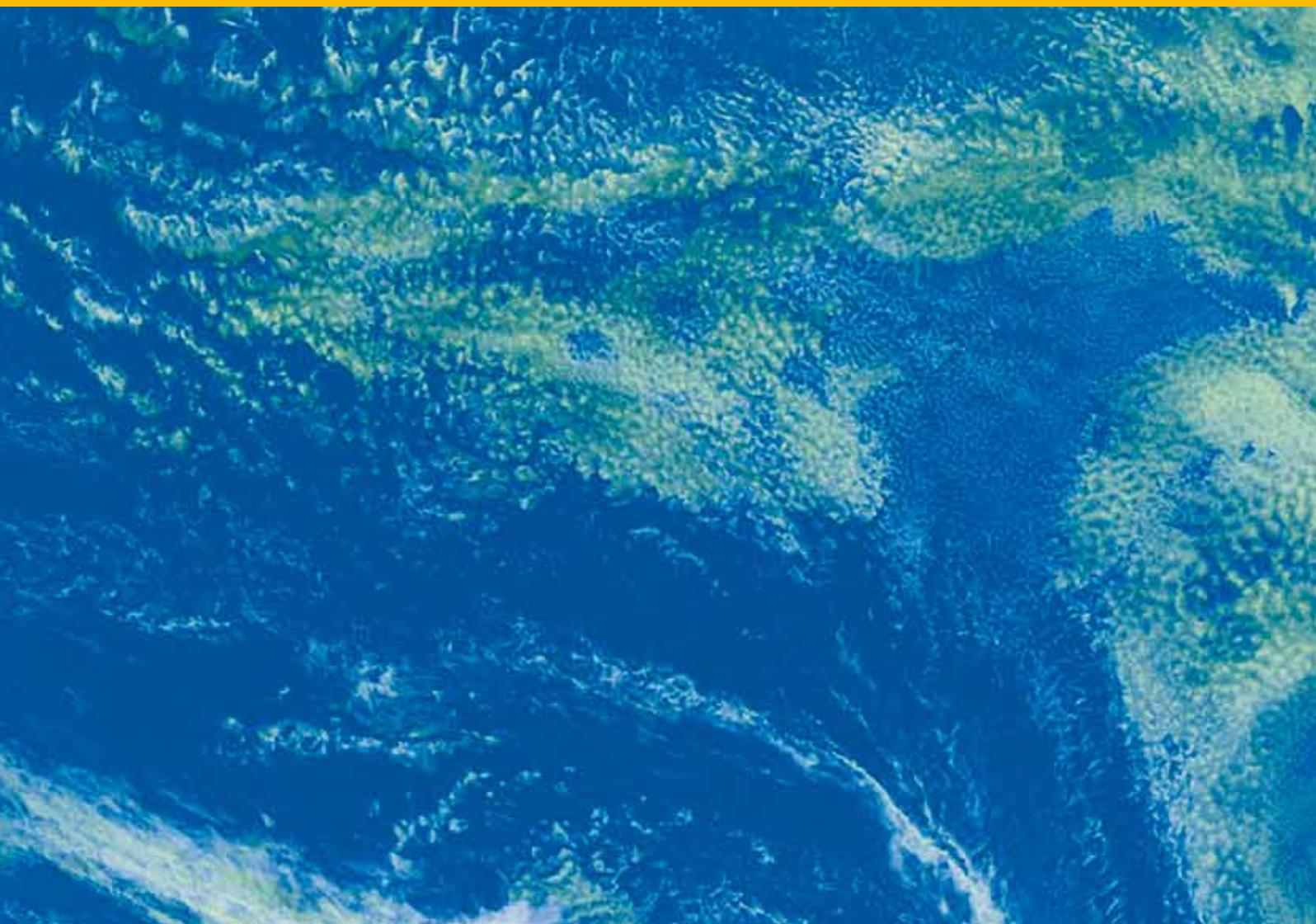
Regular reports on ongoing activities are the first step in reviewing and evaluating the German Adaptation Strategy. In parallel, the Federal Government will have suitable instruments and indicators developed (see “What is particularly at risk, and where?”, p. 51).

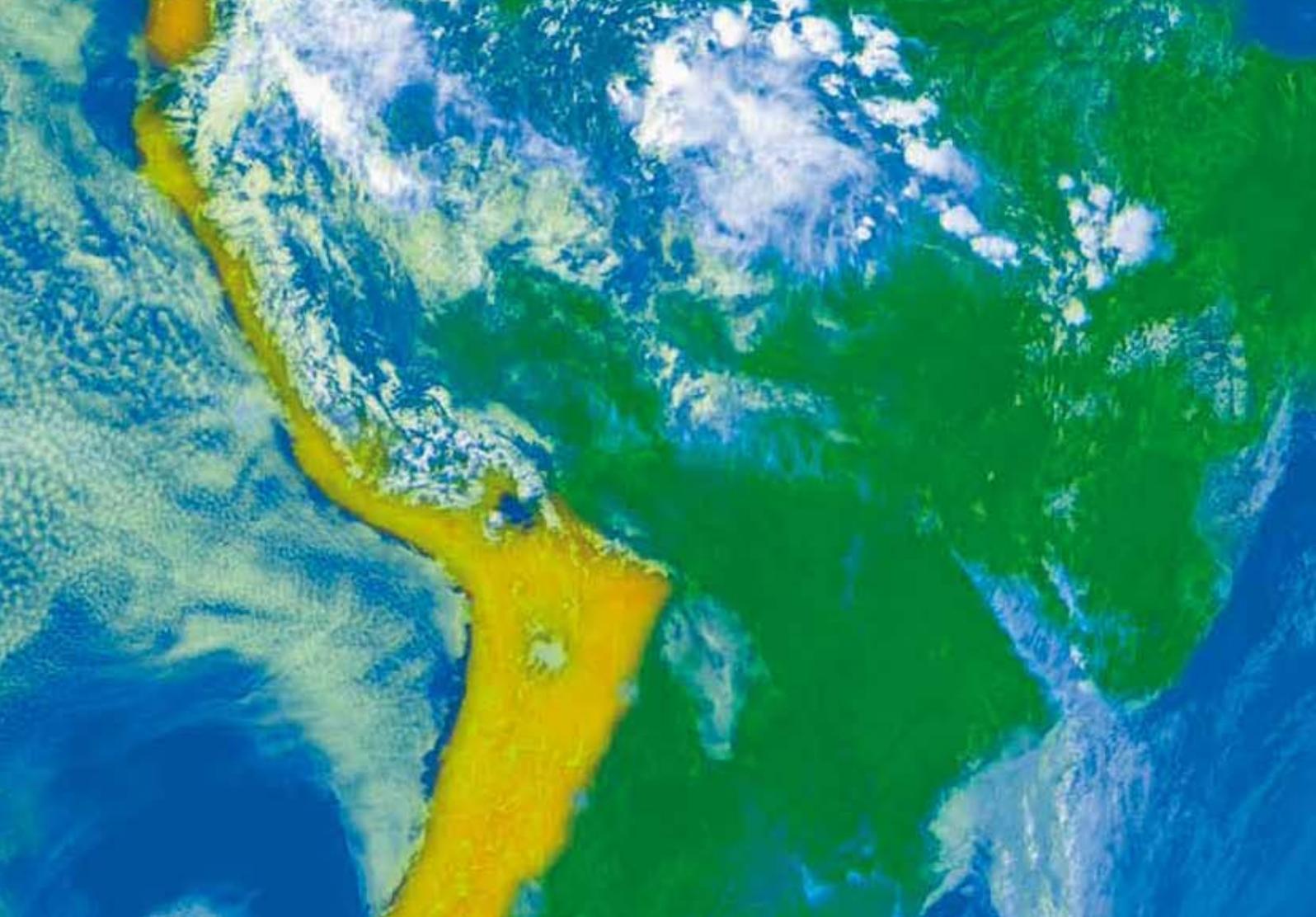


Dried-up lake in Oberes Isartal/Bavaria, April 2007



# GLOBAL ADAPTATION - THE GERMAN CONTRIBUTION







## 5.1 What is the international community doing?

Mankind must adapt to climate change and develop appropriate measures to protect itself. This was decided by the international community of states – and hence Germany – as long ago as the 1990s. Developing countries in particular, which are very vulnerable to the adverse effects of climate change, are to be assisted with the task of adapting to climate change. Although the poorer regions of the world bear little responsibility for climate change, it is apparent that they will nevertheless be greatly affected. Different institutions calculate widely differing financial requirements for adaptation. The Secretariat of the UN Framework Convention on Climate Change (UNFCCC) currently quotes an annual financial requirement of between €23 and €54 million for the developing countries in 2030 (see also [www.germanwatch.org/klima/adapt08e.pdf](http://www.germanwatch.org/klima/adapt08e.pdf)).

At the end of 2007 the Conference of the Parties, meeting on Bali, approved an action plan (UNFCCC Decision 1/CP.13) comprising four pillars: greenhouse gas reduction, adaptation, financing and technology. To this end a separate adaptation fund will start work in 2009.

This is founded on the realisation that the effects of climate change are already fuelling conflicts.

If deserts spread, drinking water is subject to regional shortages, harvests dry up, storms become more frequent or entire coastal regions are threatened by the rise in sea level, people will leave their homes. Even today, some of the worldwide migration is due to such climate change effects. The United Nations in their Security Council debate of April 2008, the EU with its decision in favour of a European action programme and the Federal Government (see [www.wbgu.de/wbgu\\_jg2007\\_engl.html](http://www.wbgu.de/wbgu_jg2007_engl.html)) have clearly stated these connections.

## 5.2 What is the Federal Government doing?

Especially in parts of Africa and on the small island states, climate change has wide-ranging effects. It could ruin progress with poverty alleviation. German development policy must therefore include climate change, especially in programmes that set out to achieve the Millennium Development Goals agreed in the year 2000. After all, there is little sense in building a school in an area that is threatened by the rise in sea level, or promoting an agri-

cultural sector that cannot expect crop yields in the future. The Federal Ministry for Economic Cooperation and Development therefore ensures a systematic “climate check” on development aid programmes and measures. The aim is to ensure that German policy really does strengthen the resistance of developing countries to climate change.

Above all, it is important to equip local people with the necessary tools for them to initiate and control the adaptation process themselves. It is also a question of helping other countries to draw up an appropriate adaptation strategy for themselves, so that they can base their development policy on it. An idea of what this can look like is provided by the existing programmes for the least developed countries, the 38 existing “National Adaptation Programmes of Action” (NAPA; see <http://unfccc.int/adaptation/napas/items/2679.php>). Providing assistance also means expanding research capacity. The Federal Government is urging that the Conference of the Parties to the UNFCCC in Copenhagen in 2009 should approve a suitably large fund to pay for adaptation measures in developing countries.

The federal budget for 2009 allocates about €5.7 billion to the portfolio of the Federal Ministry for Economic Cooperation and Development (BMZ). This is an indication that Germany is a major partner in the international fight against poverty. The figure includes support for adaptation efforts by development partners.

In addition, Germany is committed to the Nairobi work programme. This helps countries to understand and grasp the effects of climate change better. Finally, Germany is also taking part in several multilateral projects – for example the World Bank’s “Strategic Climate Fund” – and integrates the issue in its bilateral cooperation with other countries wherever this seems sensible and necessary. The principal questions here are: How will an individual country be affected by climate change, and how can it make a start on preparing for this scenario of the future? What needs to be done to reduce a country’s economic, social and political vulnerability to climate change? And who needs assistance with the adaptation process? The focus is on the sectors most badly affected: agriculture, water and health.

To support the adaptation process there is also a need to investigate where cooperation with environmental, agricultural, trade and research policy is possible. Using ecosystems in a sustainable way and managing resources carefully often permits situations that benefit everyone. In ideal cases, measures simultaneously reduce poverty, protect nature, ease the burden on the climate and implement measures necessary to adapt

to climate change. International trade agreements may also work in the same direction. One example is the EU Action Plan on “Forest Law Enforcement, Governance and Trade” (EU-FLEGT), which combats illegal logging of trees and forests.

Particularly in the poorest countries, climate change is a threat to secure food supplies. It is therefore necessary to build up a sustainable agricultural sector with a viable future. Research, advice and education are important prerequisites for this. At the same time there is a need to diversify economic structure. What specific form this takes must be examined in cooperation with the relevant countries on an individual basis and then implemented in made-to-measure programmes. Germany and other donor countries support such processes, but the responsibility rests with the developing countries. They have to establish structures that can exist in the long term without external assistance.

The alternative has far-reaching consequences – for everyone. If living conditions continue to deteriorate as a result of climate change, more and more people will leave their homes. Social tensions will pave the way for political and religious radicalisation – and further intensify the motives for flight. This could in particular affect the countries from which migration routes already exist to the European Union and adjacent regions. Research is currently in progress into the relationship between climate change and migratory movements (see for example: [www.each-for.eu/index.php?module=main](http://www.each-for.eu/index.php?module=main)). Because migration policy in the EU is designed to respond flexibly, it is in principle prepared for these demands. It also possesses instruments for cooperation with third states along the principal migration routes. By contrast, the global migration policy dialogue – e.g. within the “Global Forum Migration and Development” (GFMD) – must be expanded to include the aspect of climate change and its consequences.

## German Climate Protection Initiative

Independently of the forthcoming international decisions about how to organise a financing system that supports developing countries without taking the decisions out of their hands, the Federal Government made some €120 million available in 2008 for international adaptation and climate protection projects. The German Climate Protection Initiative is funded from revenues from emissions trading. A further €225 million is planned for international projects in 2009.

# THE ROAD TO THE ACTION PLAN





By the end of March 2011, the Federal Government intends to present an action plan for adaptation to climate change. This will build on the latest climate information and research findings. To prepare this, the Federal Government needs to and will play an active role at several levels.

## 6.1 Informing people

Adaptation frequently means changing one's habits. In many cases this means spending money. Whether people are prepared to do this depends largely on whether they expect sufficient benefits.

For the general public to be able to take competent decisions on their own responsibility, they need comprehensive and objective information. The same applies to experts, who have to assess climate change effects, probabilities and adaptation options before they plan anything. In its public relations work, the Federal Government will therefore give greater emphasis to communicating the latest findings and to publishing appropriate educational material.

## Contents of action plan

- ▶ Principles and criteria for defining and evaluating adaptation needs
- ▶ A list of the measures that the Federal Government regards as particularly important
- ▶ An overview of measures planned by other actors Information on financing possibilities
- ▶ Proposals for progress review of adaptation measures
- ▶ Further development of the German Adaptation Strategy and specification of next steps

## To do this, the Federal Government will take the following action

- ▶ Foster discussion about the German Adaptation Strategy – on a cross-sectoral basis and with a broad spectrum of actors
- ▶ Make it clear what risks Germany faces as a result of climate change, and take this as a basis for assessing where and on what scale damage can be expected if no countermeasures are taken
- ▶ Help to ensure that adaptation to climate change is always considered in future plans and decisions
- ▶ Create suitable framework conditions for developing and strengthening adaptive capacity – at ecological, technical and social level.



## 6.2 Involving many actors

The Action Plan, which will be ready in 2011, is to define responsibilities in as clear and concrete a form as possible. In order to defuse or overcome conflicts of interests ahead of decisions, mobilise individual initiative and take note of ideas and initiatives from many quarters, there is a need for relevant actors to be involved in the process from an early stage. It goes without saying that the competences laid down in the constitution have to be observed.

The Länder in particular are indispensable partners in the adaptation process. The Federal Government intends to cooperate with them even more closely to ensure a coordinated approach. The plans

already developed at Länder level need to be included in this work. In future, governments and administrations must always take the adaptation issue into account. How this is to be ensured will have to be clarified jointly.

There are a large number of adaptation measures to be planned and implemented at regional or local level. The Federal Government can help here, and it intends to do so. What form such help should take is something it wishes to discuss with the central associations of the local authorities and representatives of interested municipalities and administrative districts. Online consultations and other forms of electronic participation are to be used to involve experts and the general public. The Federal Government is also seeking a dialogue with busi-

nesses, associations, scientists and other actors in society.

With a view to elaborating the Adaptation Strategy in a dialogue to make it easier to grasp, and providing further information about the opportunities of adaptation and the risks of climate change and a forum for discussion, the Federal Environment Ministry will host the “Berlin Climate Conference - Approaches for Adaptation to Climate Change” on 18 May 2009. The conference will address initial ideas for a joint action plan. An expert workshop with local authorities will be held in conjunction with the conference on 19 May. This will be followed by expert discussions and conferences on individual aspects. The issue is also to be put on the agenda in existing dialogue, participation and advisory bodies.



## Bodies that make policies, conduct research and communicate knowledge

The Federal Government will set up an **Interministerial Working Group on Adaptation to Climate Change (IWG Adaptation Strategy)** in which all ministries are represented. It will be headed and responsibility will be borne by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. The interministerial working group will draw up the Adaptation Action Plan. Starting in 2013 it will assess at two-yearly intervals how the plan has been implemented. The working group will not only discuss the various perspectives and interests of the various ministries. It will also organise and accompany the general dialogue and discussion process.

The **Federal Government-Länder dialogue on adaptation to climate change**, initiated by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, will be carried on with a new, extended mandate. Climate change is also regularly the subject of meetings between sectoral ministries at Federal and Länder level.

In 2006 the Federal Environment Ministry established the **Competence Centre on Climate Impacts and Adaptation (KomPass)** at the Federal Environment Agency ([www.anpassung.net](http://www.anpassung.net)). This provides information about all aspects of adaptation. KomPass prepares expert knowledge in a comprehensible form and supplies it to decision makers in particular. It also has the task of networking actors, raising public awareness and providing an overview of adaptation projects.

The Federal Ministry of Education and Research gives great priority to information and advice in its High-Tech Strategy for Climate Protection. For this reason the **Climate Service Centre (CSC)** at the Helmholtz Research Centre in Geesthacht is to ensure speedy dissemination of information on the latest climate research. Furthermore, the scientists also have the task of linking different climate scenarios and models with each other and using them to derive practicable data and advisory services. The CSC coordinates its activities with KomPass and the German Weather Service to avoid duplication of work.

## One example: Dialogue with the financial services industry

Where climate change and the financial services industry are concerned, the Federal Government focuses on two main aspects: adaptation projects need to find funding. What is more, companies that produce such technologies need sufficient money to tap their market potential. The Federal Government has a dialogue partner in the “Climate Change” Financial Forum which has been set up under the High-Tech Strategy for Climate Protection.

In conjunction with the Sustainable Business Institute of the European Business School (EBS), the Financial Forum is currently drawing up a programme. This is designed to organise the dialogue between the Federal Ministry of Finance, the banks and insurance companies, and representatives of the real economy. The aim is to ensure that the financial services sector prepares for climate change in an appropriate and well-informed manner and gears its instruments to this end.



## GLOSSARY

### ▶ **Adaptation**

Adaptation denotes measures used to equip natural and artificial systems to survive the effects of climate change while suffering as little harm as possible. The measures cover a wide range. Some take precautions, others respond to changes that have already taken place. Some are initiated by the state, others by private organisations or affected individuals. Some occur independently, others are planned.

### ▶ **Adaptive capacity**

The adaptive capacity of a country depends on what institutions, skills and resources it has available.

### ▶ **Biological diversity**

Biological diversity or biodiversity covers three areas: diversity of ecosystems, diversity of species, and genetic diversity within a species.

### ▶ **Climate**

Climate in the strict sense is defined as the statistical “average weather” that prevails in a region for a period ranging from months to thousands of years. The classic period of time (= **normal climate period**), as defined by the World Meteorological Organization (WMO), is 30 years. The variables included are temperature, rainfall and wind.

### ▶ **Climate model**

A climate model uses figures to describe a climate system. Depending on its complexity, it may include a larger or smaller number of physical, chemical and biological attributes. It calculates interactions and feedback processes – for example the relationship between temperature, marine currents and ice formation. Interactive climate models are used to understand the influence of different factors, simulate changes and create forecasts.

### ▶ **Climate prediction**

A climate prediction estimates how the climate will probably develop.

### ▶ **Climate projection**

Climate projections attempt to forecast how the climate will change in response to emissions of varying quantities and types of greenhouse gas.

### ▶ **Climate variability**

Climate variability denotes the extent to which climate fluctuates in time and space around an average state. Variability may be due to natural processes within the climate system (internal variability) or may be caused by man-made influences (external variability).

### ▶ **Critical infrastructures**

These are organisations and facilities of great importance to the state, the failure or impairment of which would result in serious supply shortages, considerable disruption of public safety, or other dramatic consequences.

### ▶ **Extreme weather event, extreme event**

Any weather situation that occurs extremely rarely at a given place at this time of year is an extreme weather event. If extreme weather persists for a long period of time, it may be classified as an “extreme climate event”.

### ▶ **Regional climate model**

Regional climate models tend to use two different methods. Some examine relationships between general weather situations and the situation in smaller areas in the past. They then take the global models as a basis for deriving forecasts for the future of the regional climate. Examples include WET-TREG (weather-type-based regionalisation method) and STAR (statistical regionalisation model). By contrast, REMO (regional model) and CLM (climate local model) derive their results directly from the global climate models by creating parameters for smaller areas.

▶ **Sensitivity**

Sensitivity denotes the extent to which a natural or artificial system can be influenced by climate change. Some changes act directly, others indirectly.

▶ **SRES scenarios**

SRES scenarios are emission scenarios defined by the Intergovernmental Panel on Climate Change (IPCC), as used since 2001 in its “Special Report on Emission Scenarios”. The following terms are important for understanding the structure and use of SRES scenarios.

▶ **Scenario family:** Scenarios based on similar social, economic and technical developments. Four scenario families are described: A1, A2, B1 and B2.

▶ **Illustrative scenario:** An illustrative scenario illustrates how one should imagine the six scenario groups. In addition to the four revised scenario families (now known as A1B, A2, B1 and B2), the IPCC has constructed two additional scenarios for this purpose: A1FI and A1T.

▶ **Marker scenarios:** Marker scenarios are intended to calculate how a given scenario family or group develops under specified conditions.

▶ **Storyline:** A storyline outlines the principal features of a scenario group and describes the dynamics of its development.

▶ **Uncertainty**

Uncertainty can result from lack of information or from divergent opinions about what is or can be known. There may be many causes of uncertainty: faulty data, ambiguous concepts and terminology, or uncertainty about how people will behave. Uncertainty may be expressed in figures – for example where different climate models arrive at different forecasts about the rise in temperature. However, uncertainty may also be a qualitative statement by a team of experts.

▶ **Vulnerability**

The extent to which a system is susceptible to damage caused by climate change is known as vulnerability. Vulnerability depends on a variety of factors. External factors are the nature, scale and speed of climate change and their variations. Internal factors are the sensitivity and adaptive capacity of the system in question.

## INFORMATION AVAILABLE ON THE INTERNET

- ▶ [www.bmu.de/english/climate/adaptation\\_to\\_climate\\_change/doc/42825.php](http://www.bmu.de/english/climate/adaptation_to_climate_change/doc/42825.php): Information from the Federal Environment Ministry (BMU) on the German Adaptation Strategy for Climate Change (DAS). The strategy can be found at [www.bmu.de/42783](http://www.bmu.de/42783).
- ▶ [www.bmu.de/english/climate/aktuell/3821.php](http://www.bmu.de/english/climate/aktuell/3821.php): Information from the Federal Environment Ministry on climate change.
- ▶ [www.umweltbundesamt.de/klimaschutz-e/index.htm](http://www.umweltbundesamt.de/klimaschutz-e/index.htm): Information from the Federal Environment Agency on climate protection.
- ▶ [www.anpassung.net](http://www.anpassung.net): Address of the Competence Centre on Climate Impacts and Adaptation at the Federal Environment Agency (German only).
- ▶ [www.bmelv.de/cln\\_045/nn\\_1275682/DE/111-Nachhaltigkeit/Handlungsfeld1Klima.html\\_\\_nnn=true](http://www.bmelv.de/cln_045/nn_1275682/DE/111-Nachhaltigkeit/Handlungsfeld1Klima.html__nnn=true) [www.bmelv.de/cln\\_045/nn\\_1275682/DE/111-Nachhaltigkeit/Handlungsfeld1Klima.html\\_\\_nnn=true](http://www.bmelv.de/cln_045/nn_1275682/DE/111-Nachhaltigkeit/Handlungsfeld1Klima.html__nnn=true): Adaptation to climate change in the agricultural, forestry and fisheries sectors / Federal Ministry of Food, Agriculture and Consumer Protection (German only).
- ▶ [www.bmvbs.de/dokumente/-,302.1063353/Termin/dokument.htm](http://www.bmvbs.de/dokumente/-,302.1063353/Termin/dokument.htm): The Federal Ministry of Transport, Building and Urban Affairs provides information about the research programme on waterways and climate change (KLIWAS) (German only).
- ▶ [www.bbr.bund.de/nn\\_25610/EN/ResearchProgrammes/DemonstrationProjectsSpatialPlanning/demonstrationprojectsspatialplanning\\_\\_node.html?\\_\\_nnn=true](http://www.bbr.bund.de/nn_25610/EN/ResearchProgrammes/DemonstrationProjectsSpatialPlanning/demonstrationprojectsspatialplanning__node.html?__nnn=true): Information from the Federal Office for Building and Regional Planning on model projects in German regional policy.
- ▶ [www.bmi.bund.de/cln\\_145/DE/Themen/Sicherheit/Bevoelkerung-Krisen/Kritis/kritis\\_node.html](http://www.bmi.bund.de/cln_145/DE/Themen/Sicherheit/Bevoelkerung-Krisen/Kritis/kritis_node.html): Protection for critical infrastructures is explained by the Federal Ministry of the Interior (German only).
- ▶ [www.bmbf.de/en/502.php](http://www.bmbf.de/en/502.php): Information about climate change research findings from the Federal Ministry of Education and Research.
- ▶ [www.glowa.org](http://www.glowa.org): Results of the research programme “Global Change and the Hydrological Cycle” (GLOWA, Federal Ministry of Education and Research).
- ▶ [www.klimzug.de](http://www.klimzug.de): Here the Federal Ministry of Education and Research provides information on the programme “Klimzug” – “Managing climate change in the regions for the future”.

- ▶ **www.klimazwei.de:** The Federal Ministry of Education and Research informs about the programme on practically oriented strategies relating to climate change [www.bmbf.de/foerderungen/3165.php](http://www.bmbf.de/foerderungen/3165.php) “klimazwei – Forschung für den Klimaschutz und Schutz vor Klimawirkungen”.
- ▶ **www.wbgu.de/wbgu\_jg2007\_engl.html:** The Federal Government’s Advisory Council on Global Environmental Change considers the interactions between security conflicts and climate change.
- ▶ **www.bundesregierung.de/Content/DE/\_\_\_Anlagen/2008/05/2008-05-08-fortschrittsbericht-2008,property=publicationFile.pdf:** The Federal Government’s progress report on the National Sustainability Strategy (German only).
- ▶ **www.gtz.de/de/dokumente/de-klima-anpassung-info.pdf:** The Gesellschaft für Technische Zusammenarbeit (GTZ) explains the reasons for and effects of climate change and offers various adaptation options (German only).
- ▶ **www.dwd.de:** Information from the German Weather Service on climate and climate change.
- ▶ **www.klimabuero.de, www.norddeutsches-klimabuero.de, www.sueddeutsches-klimabuero.de, www.ufz.de/index.php?de=17016, www.klimabuero-polarmeer.de:** The regional climate offices of the Helmholtz Association offer information on climate modelling, climatic impacts of climate change, and extreme events (German only).
- ▶ **www.ufz.de/index.php?en=16028:** The Helmholtz Centre for Environmental Research investigates the complex interactions between man and the environment in relation to climate change. The proceedings of the research symposium on the German Adaptation Strategy can be found at [www.ufz.de/index.php?de=16735](http://www.ufz.de/index.php?de=16735) (German only).
- ▶ **http://ec.europa.eu/environment/climat/home\_en.htm:** Information from the European Union (EU) on climate change.
- ▶ **http://eur-lex.europa.eu/LexUriServ/site/en/com/2007com2007\_0354en01.pdf:** EU Green Paper on adaptation to climate change.
- ▶ **www.eea.europa.eu/de/themes/climate:** Address of the European Environment Agency, focus on climate.
- ▶ **www.each-for.eu/index.php?module=main:** The European Commission’s programme EACH-FOR studies the relationship between migration and climate change.

- ▶ [www.ipcc.ch](http://www.ipcc.ch): Intergovernmental Panel on Climate Change.
- ▶ <http://unfccc.int/adaptation/items/4159.php>: United Nations Framework Convention on Climate Change, focus on adaptation.
- ▶ [www.who.int/en](http://www.who.int/en): World Health Organization.
- ▶ [www.wmo.int/pages/index\\_en.html](http://www.wmo.int/pages/index_en.html): World Meteorological Organization.

### Länder websites on climate protection, climate change and adaptation

- ▶ [www.umweltministerkonferenz.de/uploads/Endgueltiges\\_Ergebnisprotokoll\\_UMK\\_d10.pdf](http://www.umweltministerkonferenz.de/uploads/Endgueltiges_Ergebnisprotokoll_UMK_d10.pdf): Statement by the Länder on the German Adaptation Strategy (German only).

#### Baden-Württemberg

- ▶ [www.lubw.baden-wuerttemberg.de](http://www.lubw.baden-wuerttemberg.de)
- ▶ [www.lubw.baden-wuerttemberg.de/servlet/is/2908](http://www.lubw.baden-wuerttemberg.de/servlet/is/2908)
- ▶ [www.kliwa.de](http://www.kliwa.de)

#### Bavaria

- ▶ [www.klima.bayern.de](http://www.klima.bayern.de)
- ▶ [www.kliwa.de/](http://www.kliwa.de/)

#### Brandenburg

- ▶ [www.mluv.brandenburg.de/cms/detail.php/1\\_07283](http://www.mluv.brandenburg.de/cms/detail.php/1_07283)
- ▶ [www.mluv.brandenburg.de/info/mk\\_klimaschutz](http://www.mluv.brandenburg.de/info/mk_klimaschutz)

#### Berlin

- ▶ [www.berlin.de/sen/umwelt/klimaschutz/index.shtml](http://www.berlin.de/sen/umwelt/klimaschutz/index.shtml)

#### Bremen

- ▶ [www.umwelt.bremen.de/klimaschutz](http://www.umwelt.bremen.de/klimaschutz)

#### Hamburg

- ▶ [www.hamburg.de/klimawandel](http://www.hamburg.de/klimawandel)
- ▶ [www.klima.hamburg.de/index.php?id=214](http://www.klima.hamburg.de/index.php?id=214)
- ▶ <http://klimzug-nord.de/cms>

### Hesse

- ▶ [www.hm.ulv.hessen.de/irj/HMULV\\_Internet?cid=5ec6add988184f55cc1af07c8e8b96bd](http://www.hm.ulv.hessen.de/irj/HMULV_Internet?cid=5ec6add988184f55cc1af07c8e8b96bd)
- ▶ [www.hlug.de/klimawandel/inklim/index.htm](http://www.hlug.de/klimawandel/inklim/index.htm)
- ▶ [www.hm.ulv.hessen.de/irj/HMULV\\_Internet?cid=dd16dc7471467919427f8c8c0e227d75](http://www.hm.ulv.hessen.de/irj/HMULV_Internet?cid=dd16dc7471467919427f8c8c0e227d75)
- ▶ [www.klimzug-nordhessen.de](http://www.klimzug-nordhessen.de)

### Mecklenburg-Western Pomerania

- ▶ [www.wm.mv-regierung.de/Publikationen/NachhaltigeEntwicklung](http://www.wm.mv-regierung.de/Publikationen/NachhaltigeEntwicklung)
- ▶ [www.regierung-mv.de/cms2/Regierungsportal\\_prod/Regierungsportal/de/wm/\\_Service/Publikationen/index.jsp?&publikid=1239](http://www.regierung-mv.de/cms2/Regierungsportal_prod/Regierungsportal/de/wm/_Service/Publikationen/index.jsp?&publikid=1239)
- ▶ [www.regierung-mv.de/cms2/Regierungsportal\\_prod/Regierungsportal/de/wm/Themen/Energieland\\_2020/Fachinformation\\_Kli](http://www.regierung-mv.de/cms2/Regierungsportal_prod/Regierungsportal/de/wm/Themen/Energieland_2020/Fachinformation_Kli)
- ▶ [http://service.mvnet.de/\\_php/download.php?datei\\_id=2105](http://service.mvnet.de/_php/download.php?datei_id=2105)

### Lower Saxony

- ▶ [www.umwelt.niedersachsen.de/master/C916711\\_N11286\\_L20\\_D0\\_I598.html](http://www.umwelt.niedersachsen.de/master/C916711_N11286_L20_D0_I598.html)
- ▶ [www.umwelt.niedersachsen.de/master/C48561565\\_N11441\\_L20\\_D0\\_I598.html](http://www.umwelt.niedersachsen.de/master/C48561565_N11441_L20_D0_I598.html)

### North-Rhine/Westphalia

- ▶ [www.klimawandel.nrw.de](http://www.klimawandel.nrw.de)

### Rhineland-Palatinate

- ▶ [www.klimawandel-rlp.de](http://www.klimawandel-rlp.de)
- ▶ [www.mufv.rlp.de](http://www.mufv.rlp.de)
- ▶ [www.kliwa.de](http://www.kliwa.de)

### Saarland

- ▶ [www.saarland.de/klimaschutz\\_wandel.htm](http://www.saarland.de/klimaschutz_wandel.htm)

### Saxony

- ▶ [www.klima.sachsen.de](http://www.klima.sachsen.de)

### Saxony-Anhalt

- ▶ [www.mu.sachsen-anhalt.de/start/main.htm](http://www.mu.sachsen-anhalt.de/start/main.htm)
- ▶ [www.mlu.sachsen-anhalt.de](http://www.mlu.sachsen-anhalt.de)

### Schleswig-Holstein

- ▶ [www.schleswig-holstein.de/UmweltLandwirtschaft/DE/ImmissionKlima/06\\_\\_Klimaschutz/klimaschutz\\_\\_node.html](http://www.schleswig-holstein.de/UmweltLandwirtschaft/DE/ImmissionKlima/06__Klimaschutz/klimaschutz__node.html)

### Thuringia

[www.thueringen.de/de/tmlnu](http://www.thueringen.de/de/tmlnu)

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