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Climate Change in Germany

Vulnerability and Adaptation Strategies of Climate-Sensitive Sectors

- Summary -

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This report is the result of a study conducted by the Potsdam Institute for Climate Impact Research (PIK), commissioned and financed by the Federal Environmental Agency, Germany (Umweltbundesamt, UBA), and carried out between March 1st, 2003 and June 30th, 2005.

1 Objectives

The objectives of this study were

1. to document existing knowledge on global change (and particularly climate change) in Germany and analyse its current and potential future impacts on seven climate-sensitive sectors (water management, agriculture, forestry, nature conservation, health, tourism and transport),

2. to evaluate the present degree of adaptation and the adaptive capacity of these climate-sensitive sectors to global change,

3. to draw conclusions on the vulnerability to global change of sectors and regions in Germany by considering potential global change impacts, degrees of adaptation and adaptive capacity,

4. to discuss the results of the study with decision-makers from government, administration, economy, and society, in order to develop a basis for the development of strategies of adaptation to global change in Germany.

2 The concepts of vulnerability and adaptive capacity

The term vulnerability refers to the risks of damage to human-environment systems. This study is concerned with the vulnerability to global change, with special attention to climate change. There are direct effects of global change on human beings (e.g., by floods or heat waves), and indirect effects through impacts of global change on climate-sensitive sectors (e.g., water management or agriculture).

Vulnerability to present and future global change is highly dependent on the initial situation. Often a region or sector is under pressure already today. Current climatic or local environmental conditions can impose restrictions (e.g., low precipitation or poor soils limit agriculture and forestry). Many sectors are affected by changes in socio-economic circumstances (e.g., agriculture, forestry, health, tourism, transport). Such circumstances determine to a large extent the predisposition of a region or sector to impacts of global change and are largely responsible for the regional differentiation of vulnerability.

In addition to this predisposition, the vulnerability of a human-environment system, a region or sector to global change depends mainly on three factors:

- What is the degree of climate change and other elements of global change in the specific region?
- What are the potential impacts of global change in the region on the different sectors?
- What is the degree of adaptation of the specific sectors within the region to these potential impacts?

The degree of adaptation is determined by the presence of adaptation measures, which can prevent damage or make use of favourable opportunities.

The assumption of an unchanged state of adaptation in the future results in a vulnerability *without* further adaptation (business-as-usual scenario). This vulnerability is also described as the *current vulnerability*. In determining this vulnerability it is assumed that in addition to the existing measures (e.g., in flood protection) no further measures will be taken in the future. The current vulnerability gives an idea of the damage that has to be expected if no further adaptation measures to global change (particularly climate change) are taken. In this study the current vulnerability is presented on a qualitative scale with three categories (small – medium – high vulnerability). A quantitative vulnerability index is deliberately avoided, since such an index would pretend a precision that does not exist – neither with regard to potential impacts of global change nor concerning the adaptation to such impacts.

The assumption of a fully used existing adaptive capacity in order to improve the future degree of adaptation results in a vulnerability *with* further adaptation (improved-business scenario). As before, the vulnerability with further adaptation is assessed on a qualitative scale with three categories (small – medium – high vulnerability). Comparison of the vulnerability *without* further adaptation (business-as-usual scenario) and the vulnerability *with* further adaptation (improved-business scenario) renders an idea of the damage from global change (particularly from climate change) with and without further adaptation.

Therefore, vulnerability of a human-environment system exists only if this system is not adapted to the potential impacts of global change. The degree of adaptation is determined by the adaptive capacity of the human-environment system. The adaptive capacity is small if the necessary resources (financial, organisational, legislative, knowledge, etc.) to implement a sufficient degree of adaptation are lacking. In this case the human-environment system will not be able to adapt to the impacts of global change.

3 Methods

In order to reach the objectives stated above we relied on the results of a European research project (ATEAM[1]), which was coordinated by PIK. These results are based on a set of consistent, spatially explicit scenarios of global change, a range of ecosystem models and indicators for ecosystem services, as well as a continuous dialogue with stakeholders. The bulk of scientific information on global change and its potential impacts in this report is drawn from analyses of the results of the ATEAM project. In addition to the ATEAM results, numerous studies and projects on national and regional scale were consulted.

To gain estimations of the regional and sector-specific significance of potential impacts of climate change, of the existing degree of adaptation and of suitable adaptation measures, surveys of climate-sensitive sectors (forestry, agriculture, water management, tourism, nature conservation, health, and transport) were carried out in various regions of Germany.

To assess vulnerability, the scenarios of potential impacts of global change in Germany (from the ATEAM and other projects) were integrated with results from the surveys.

The results were discussed during several “Expert Talks on Climate” (Klimafachgespräche) which were organised by the Federal Environment Agency (UBA) and during a stakeholder workshop with representatives from government, administrative bodies, the economy, and the wider public.

4 Global Climate Change – Historical Development

The rate and degree of climate change, which took place during the 20th century are unprecedented – for example the current temperatures on the Northern Hemisphere are probably the warmest for at least 2000 years. The 1990s were the warmest decade, and the years 1998, 2002 and 2003 were the three warmest years in the last thousand years in the Northern Hemisphere. Since 1900 the global mean temperature has risen by 0.7 ± 0.2 °C. Precipitation over the middle and high latitudes of the Northern Hemisphere increased by 0.5 to 1% per decade in the 20^{th} century, while it decreased over the subtropical latitudes. Furthermore, climate extremes were observed more frequently, such as for example an accumulation of temperature anomalies in the Pacific Ocean since 1970 (so called “El Niño events“). Since 1950, there has been a pronounced increase in the damage caused by natural disasters and flooding.

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[1] ATEAM – Advanced Terrestrial Ecosystem Analysis and Modelling (EU Project No. EVK2-2000-00075), www.pik-potsdam.de/ATEAM.

Only a small fraction of this climate change can be explained by natural factors such as eruptions of volcanoes, changes in solar activity or deviations in the Earth's orbit around the sun. In the scientific community there is overwhelming consensus that the main cause of climate change is human activity, in particular the emission of greenhouse gases. In a few generations we are using up fossil fuels that took hundreds of millions of years to form, in order to meet our energy demands. Burning of fossil fuels produces greenhouse gases, e.g. carbon dioxide. Greenhouse gases such as water vapour, carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) reflect part of Earth's heat radiation (infrared radiation) and thereby cause a "greenhouse effect" that is warming the atmosphere and the Earth's surface.

Since the beginning of industrialisation the atmospheric concentration of the most important greenhouse gas CO_2 has risen by 34% from 280 to 375 ppm, due to burning of fossil fuels and land-use change, and has probably reached its highest level in 400'000 years. Over the same time the concentration of methane, the second most important greenhouse gas, has even risen by more than 150%. In the absence of drastic measures to reduce emissions, the atmospheric carbon dioxide concentration is expected to double even within the next few decades (to almost 600 ppm, relative to pre-industrial level).

5 Global Climate Change – Projections of Future Development

The European Union is committed to keeping global warming below 2ºC, relative to pre-industrial temperatures, in order to prevent "dangerous clime change" (see Article 2 of the UNFCCC). Climate sensitivity, that is the rise in temperature following a doubling of the CO_2 concentration, is assumed to lie between 1.5 and 4.5ºC globally. The probability of overshooting the 2-degree target in the long term rises rapidly under concentrations that lie much higher than today's values. To reach the 2-degree target, today's global emissions need to be lowered from 7 Gt carbon per year to 2 Gt per year. This is a formidable challenge, in view of the emissions of the United States of America and of densely populated countries such as India and China that also exhibit rapid economic growth. The projection of emission trajectories is very uncertain. In this study we use the SRES scenarios published by the IPCC. They do not consider any explicit climate policy, but nevertheless embrace a range of emissions that are possible in the light of today's climate policy strategies.

The IPCC acts on the assumption of the continued increase of all greenhouse gas concentrations to values of between 650 and 1215 ppm CO_2 equivalents. The carbon dioxide concentration alone will therefore rise to values of between 607 and 958 ppm, ranging between a doubling and a tripling of pre-industrial levels. In consequence, a continued, accelerated rise in global mean temperature by 1.4-5.8ºC is expected by the year 2100. Global average precipitation is expected to rise slightly, with a very heterogeneous distribution over space and time.

The exact prediction of extreme clime events is currently impossible. However, extreme weather and climate events, such as hot summer days, summer drought and extreme rainfall will probably or very probably occur more frequently during the 21st century. Moreover an increase in cyclone activity in the tropics is likely. A decrease in cold extremes is very likely.

6 Global Change in Germany – Historical Trends in Climate

Long-term weather recording shows that Germany is already affected by climate change. Regarding *temperature* development, the 1990s were observed to be the warmest decade in Germany during the 20th century, in accordance to the global observation. The annual average temperature increased by ca. 0.8 to 1ºC between 1900 and 2000. However, this warming did not occur linearly. A strong warming up to 1911 was followed by a heterogeneous period. The 1940s were exceptionally warm. After a cooling trend up to the 1970s we now observe a continuous and rapid temperature increase that still continues today. There is strong regional variation. In the last decade (1990s), the temperature rise in southern and south-western Germany was exceptionally strong. Observations on seasonal trends in the warming depend on period in time and method. During the last twenty years a trend toward stronger temperature increase in winter than in summer has been observed. For example, the temperature increase in the winter months in Germany during the period between 1981 and 2000 was 2.3ºC, while in the summer months it was merely 0.7ºC.

Precipitation in Germany is characterised by strong regional and seasonal variations. In the long term, neither the average values nor the seasonal or regional distribution show significant trends. During the last 100 years there has been a small trend towards increased winter precipitation, but this trend is not significant. In the last 30 years, however, there was indeed a definite increase in winter precipitation. Summer precipitation in contrast showed little change.

Changes in the *duration of snow cover* are also relevant. Since 1950, a decrease by 30-40% in the duration of snow cover has been observed in altitudes below 300m in Bavaria and Baden-Württemberg. In the medium altitudes (300-800m) the decrease was 10-20%. In higher altitudes over 800m only small decreases and in places even increases were observed, due to increased winter precipitation and sufficiently low temperatures for snowfall.

There is only partial evidence for an increase in *climate extremes*, such as heat waves, extreme rainfalls and storms. *Extreme heat events*, such as heat days (T>30ºC) or heat waves (intervals of more than three days during which the maximum daily temperature lies above a certain high threshold, relative to the specific temperature standard of the weather station) exhibit a definite trend. For example, the probability of occurrence of heat days in the months of July and August has risen over the last one hundred, and especially markedly during the last twenty years at almost all weather stations in Germany. The intensity and frequency of occurrence of *extreme rainfall events* have increased especially during the last forty years of the 20th century. In general, this trend is more pronounced in the winter than in the summer. The intensity and frequency of occurrence of *squalls* have also been investigated. However, at present no statistically significant trend can be found. There is a tendency of increased probability of occurrence of extremely high daily wind speed maxima (Bft > 8) during winter (with the exception of coastal regions), and decreased occurrence of such maxima in summer (with the exception of southern Germany).

7 Global change in Germany – Scenarios of Future Climate Change

With regard to future *temperature* development, all ATEAM scenarios that were analysed in this study exhibit a definite warming trend for Germany. The range of warming of the long-term annual average temperatures up to the year 2080 within the seven climate scenarios considered was +1.6 to +3.8ºC. Many scenarios show a particularly strong warming in the south-west, in some cases also in the far east of Germany. The scenarios exhibit heterogeneous seasonal changes. The trend of stronger warming during winter, observed in the past, cannot be found in the future scenarios.

All climate scenarios show very small changes in annual *precipitation,* which lie mostly below 10% up to the year 2080. Stronger trends can be found in winter and summer precipitation. All seven climate scenarios show an increase in winter precipitation, while most scenarios show a decrease in summer precipitation. This is in accordance with the observed trend of a shift of precipitation into the winter half year. An especially pronounced increase in winter precipitation was projected for Southern Germany, at least in the scenarios that are based on the climate model HadCM3. In these scenarios, the decrease of summer precipitation is concentrated on Southwest Germany (Rhineland) and central parts of Eastern Germany. However, the projections of the other climate models partly produce regionally contradicting trends.

8 Vulnerable Regions in Germany

In summary of the results on vulnerability *without* further adaptation (business-as-usual scenario) on the different sectors, separated by region (environmental zone), the highest vulnerability to climate change within the selected climate-sensitive sectors is exhibited by Southwest Germany (upper Rhine rift), the central parts of Eastern Germany (North-Eastern lowland, South-Eastern basin and hills), and the Alps (see Tab. 7-1). The lowest vulnerability is assessed for the German low mountain ranges and Northwest Germany.

In *Eastern Germany* (North-Eastern lowland, South-Eastern basin and hills), low water availability and the risk of summer droughts account for the high current vulnerability in many sectors. The present unfavourable climatic water balance will be exacerbated by the already observed and further expected decrease in summer precipitation, as well as by increased evaporation due to increased temperatures. This will in particular impact agriculture and forestry, as well as the transport sector (navigation). Additionally, there is a high vulnerability with respect to flooding in the large river basins of the Elbe and Oder. In the Lausitz, where particularly high summer temperatures are expected, the current vulnerability in the health sector is high, owing to strong heat stress.

In *Southwest Germany* (upper Rhine rift) especially the high temperatures will cause problems. This region, where the highest temperatures are measured today, is expected to show the strongest warming in Germany in the future. This causes high vulnerability *without* further adaptation in the health sector. Furthermore, agriculture and forestry are highly vulnerable to rapid warming. Moreover, the risk of flooding in the early spring increases, owing to a shift of precipitation from summer to winter, as well as an increase in extreme rainfall events.

The sensitivity of many sectors is the main reason for the high vulnerability *without* further adaptation in the *Alps*, in addition to expected climate change, which is slightly above average in the Alpine region. Especially in the nature conservation sector, the Alps are very vulnerable, because they are characterised by many endemic plant and animal species, which hardly have any migratory alternatives when climate changes. Furthermore, the abundance of unique microclimatic locations and azonal biotopes increases vulnerability. In the Alps the risk of flooding is particularly high, owing to the lack of retention areas. Finally, the winter tourism sector is highly sensitive and not very adaptive to a decrease in snow safety.

In comparison, the German *low mountain ranges* currently show medium vulnerability. At present the climate in these regions is cool and moist, so that a change to a warmer climate can actually pose an opportunity for some sectors (e.g. agriculture). There is high vulnerability against flooding, especially for local high water events, caused by convective extreme rainfall events. Winter tourism, if present, also shows high current vulnerability.

Similar to the low mountain ranges, the *coastal regions* exhibit only medium vulnerability. However, there is high current vulnerability caused by possibly more intensive storm surges. Moreover, the immediate coastal areas are threatened by the rising sea level. But the implementation of adaptation measures has already advanced relatively far. In other sectors coastal regions may well profit from climate change. This concerns the sectors agriculture and forestry, as well as tourism, which will profit from rising summer temperatures and decreasing summer precipitation.

The lowest current vulnerability was assessed for Northwest Germany. Climate change will probably be least pronounced in this region, because it is attenuated by oceanic effects. Due to the presently very moderate climate, most sectors exhibit a wide range of tolerance. Again, the sectors agriculture and tourism, and with some limitations also forestry, may potentially profit from climate change.

Tab. 7-1: Summary of vulnerability to global change (particularly climate change) in Germany without further adaptation (business-as-usual scenario). Vulnerabilities in almost all sectors and regions could probably be reduced to a low level, if all potential measures of adaptation in the specific sectors and regions were implemented (improved-business scenario).

Sector / Environmental zone	Water		Agriculture	Forestry	Nature conservation	Health		Tourism		Transport	All sectors
	Flood	Drought				Heat stress	Vector-borne diseases	Winter tourism	Other forms of tourism		
Coastal zone	– – (1)	~	~	~	–/– –? (2)	~	–?	n.d.	–	–	–
North-West German lowland	– –	~	~	~	–/– –? (2)	~	–?	n.d.	–	–	–
North-East German lowland	– –	– –	– –	– –	–/– –? (2)	–	–?	n.d.	–	–	– –
West German lowland bay	– –	–	–	–	–/– –? (2)	– –	– –?	n.d.	–	–	–
Central low mountain ranges and Harz	– –	–	~	–	–/– –? (2)	–	–?	– –	–	–	–
South-Eastern basin and hills	– –	– –	– –	– –	–/– –? (2)	– –	– –?	n.d.	–	–	– –
Erz Mountains, Thuringian and Bavarian Forest	– –	–	–	–	–/– –? (2)	–	– –?	– –	–	–	–
Low mountain ranges left and right of Rhine	– –	–	–	–	–/– –? (2)	–	– –?	– –	–	–	–
Upper Rhine rift	– –	–	–	– –	–/– –? (2)	– –	– –?	n.d.	–	–	– –
Alp and North-Bavarian hills	– –	–	–	–	–/– –? (2)	–	– –?	– –	–	–	–
Alpine foothills	– –	–	–	– –	–/– –? (2)	–	– –?	n.d.	–	–	–
Alps	– –	~	~	–	– –	~	–?	– –	–	–	– –
Germany	– –	–	–	–	–/– –? (2)	–	– –?	– –	–	–	–

Rating:

– – high vulnerability

– moderate vulnerability

~ low vulnerability

? High uncertainty or difficulty of evaluation

n.d. - no data

Rating „all sectors“:

high vulnerability, if more than 2 sectors high

moderate vulnerability, if 1-2 sectors high

low vulnerability, if no sector high

(“half“ sectors count as half)

Rating “Germany“: mean value

(1) Storm surges and sea level rise

(2) Vulnerability dependent on conservation goal.
- Conserving status quo: high vulnerability
- Conserving processes: moderate vulnerability

Besides these portrayed regions and environmental zones (see Tab. 7-1), *wetlands* and *congested urban areas* show high vulnerability without further adaptation. In wetlands, especially the sectors water and nature conservation are highly vulnerable. In congested urban areas, especially the sectors health (heat stress) and transport will be affected.

The vulnerabilities in most regions could probably be lessened to a low level, if all available potential adaptation measures were implemented in the specific regions and environmental zones (improved-business scenario). However, in most regions adaptation measures to climate change are neither planned nor implemented. In the Alpine region, vulnerability can probably only be reduced to a medium level, since the adaptive capacity to the potential impacts of climate change on winter tourism, biodiversity and flood risk is limited.

9 Vulnerable Sectors in Germany

Looking at the vulnerability of different climate-sensitive sectors, especially the sectors water, health and winter tourism appear highly vulnerable.

In all parts of Germany current vulnerability is high in the *water* sector, due to increasing flood risk and high potential for damage. Further regional differentiation of the expected impacts is currently not possible due to the uncertainties related to the modelling of regional precipitation patterns. In addition, the risk of droughts is increasing, particularly in Eastern Germany. Currently, few adequate adaptation measures to this stress are locally available. This results in locally high current vulnerability. However, for the entire country there appears to be only moderate current vulnerability to droughts in Germany.

The *agricultural sector* is primarily impacted by aridity in summer. Climate change also impacts indirectly through increased risk of diseases and pest outbreaks. However, the agricultural sector can adapt to changed climate and weather condition on a short-term basis due to its large choice of crop types and varieties, as well as short rotation times. Therefore, the agricultural sector seems to be only moderately vulnerable to climate change without further adaptation specifically to climate *change*. Vulnerability is rated to be high merely in the drought-prone areas of Eastern Germany with poor soils.

Similarly, the *forestry sector* is impacted by aridity and increased risk of diseases and pests. In addition, there is increased risk of forest fires and extreme events. The forestry sector has limited adaptive capacity due to long rotation times and high costs. Drought-prone areas (Eastern Germany), as well as regions with a high proportion of out-of-natural-habitat spruce stands (lower regions in Western and South-Western Germany) are rated as highly vulnerable. In general, the forestry sector is classified as moderately vulnerable to climate change.

To rate vulnerability in the sector *nature conservation* is especially difficult. Definite impacts of climate change are expected (shifts in species' distribution, changes in species communities etc.), however, there is no consensus on the relevance of these impacts. The current vulnerability is rated as moderate to high, depending on the conservation goal. Adaptation measures (e.g. improved connections within the conservation network) can only support natural processes (e.g. migration), but clearly cannot conserve the current community of species.

Without further adaptation, the *health sector* is rated as regionally highly vulnerable to impacts of heat waves, generally in Germany as moderately vulnerable. High uncertainty exists with regard to climate change impacts on vector-borne diseases. Nevertheless, due to the high potential risk and the current lack of adaptation the vulnerability to vector-borne diseases seems to be high.

In the *tourism sector*, winter sports particularly are classified as highly vulnerable. Decreasing snow safety must be expected, for which no adequate long-term adaptation measures are available. Other forms of tourism are moderately vulnerable. Leisure-oriented summer tourism will probably profit from climate change. To date, there has been little debate on vulnerability to climate change in the German tourism sector.

The *transport sector* is primarily at risk due to a potential rise in the frequency of extreme events (storms and extreme rainfall events), as well as due to extreme heat in summer. This impacts both the flow of traffic and the infrastructure. In winter, the transport sector is likely to profit from climate change (less frost days). In general, the vulnerability of the transport sector is rated as moderate. Navigation is likely to be the area of highest impact, due to strongly fluctuating water levels of rivers. As with tourism, to date, there has been little debate on vulnerability to climate change in the German transport sector.

The vulnerabilities in most sectors could probably be lessened to a low level, if all in the specific sectors available potential adaptation measures were implemented (improved-business scenario). In the nature conservation sector alone, vulnerability can probably be reduced only to a moderate degree due to limited adaptation options.

However, in most sectors – as well as in most German regions – adaptation measures to climate change are neither planned nor implemented. Consequently there is an urgent need for action.

10 Recommendations for Adaptation Strategies

In addition to specific adaptation needs in different sectors and regions we identify several general challenges for adaptation in Germany. To reduce our vulnerability to climate change both measures to adapt to impacts of climate change, as well as measures to reduce greenhouse gas emissions, which are decisively responsible for climate change, have to be implemented. Adaptation measures to reduce negative impacts and to take advantage of positive impacts are necessary, because climate change is already taking place, and will continue to happen. Due to the inertia of the climate system, climate change would continue for several centuries even after a highly unlikely immediate reduction of greenhouse gases. Emission reductions are nevertheless indispensable for a long-term reduction of vulnerability. Further warming of our global climate beyond the adaptive capacity of Germany and the world can only be counteracted by emission reductions. Adaptation measures and emission reduction are therefore not alternative strategies, but have to be carried out in parallel.

In Germany, outside the scientific community climate change is discussed so far almost exclusively in the context of the need for emission reductions. Adaptation to the impacts of climate change has only recently received more attention, but is still highly under-represented in public awareness and in the consciousness of decision-makers in economy, policy and administration. The first step to a Germany that is adapted to climate change therefore must be to create awareness of the risks and opportunities. To do so, the existing public awareness of the existence of climate change should be used, as well as extreme weather events (extreme rainfall events, heat waves etc.) that provide “windows of attention” for the climate problem. The existing link between risks and opportunities of climate change and the dominating political themes in Germany (unemployment, economic growth etc) should be stressed, in order to secure public attention to the debate beyond the context of weather extremes. When communicating the potential impacts of climate change, the inherent uncertainties of the scenarios need to be made transparent; failure to do so will result in dented credibility, when exact predictions are not met. The risks of climate change can trigger mechanisms of repression or even fatalistic reactions (“I cannot do anything anyway.”). To prevent such reactions from the start, “catastrophism” – i.e. stressing potential climate impacts of catastrophic extent – should be avoided. The communication of risks should always be linked to the communication of possible adaptation measures. Role models are particularly suited to communicate adaptation measures by providing a living example.

Creating awareness of potential impacts can only be a first step to a Germany that is adapted to climate change. As when communicating risks and opportunities, the uncertainty in the assessment of potential impacts of climate change is a special challenge when concrete decisions about adaptation measures have to be made, e.g.

the raising of dykes to face increasing flood risk. With regard to the precautionary principle, it is an irresponsible strategy to wait for less uncertain assessments before implementing adaptation measures, since climate change and its impacts are already taking place. Furthermore, waiting for less uncertain scenarios is a treacherous hope; the results will remain uncertain in future even with increased refinement of scientific methods. Decision-makers often lack awareness of systematic and conscious strategies to make decisions in the face of uncertainty. Therefore support is needed. In this respect the 8-stage decision support system for decision-making about adaptation to climate change, which is introduced in this report, is a first stimulus.

Often adaptation to the impacts of climate change will only be possible if responsibilities are shared between different actors. Ultimately, climate change adaptation – just like the reduction of greenhouse gas emissions – is a task for society as a whole, to which every single citizen, as well as actors from the economy, the political sphere, administration, the media, nature conservation organisations, education and research can and should contribute. Science and education are of special importance in this, due to the complexity of the climate problem. The media will be of significant relevance in communicating potential climate impacts and necessary adaptation measures to the public. Nature conservation organisations also play a major role in this communication. Politicians and administrators must create the necessary financial, legal and organisational conditions. Administrative bodies have the additional function of informing and coordinating adaptation measures in private industry and households; this is an especially significant function in view of the current budgetary position in many communities, federal states and in the federal government. In addition to the climate-sensitive sectors that were analysed in this study (forestry, agriculture, water, tourism, nature-conservation, health and transport), further adaptation measures are necessary in other sectors (e.g., the construction sector). Finance (banks and insurances) is of central importance; it possesses decisive instruments for the regulation of adaptation through the granting of loans and insurance. Finally, every German citizen needs to adapt, e.g. through taking increased precaution against tick bites or through building structures that are adapted to higher flood risk.

Dialogue and coordination between different actors in the process of adaptation should be facilitated, since climate adaptation is a task for society as a whole. Networking is an efficient instrument for this. These networks should be organised not only within Germany, but also seek contacts outside the country: some countries have far more experience with climate change adaptation than Germany. A network of adaptation actors has already started to form through the efforts of the Federal Environment Agency (UBA) to initiate and build a “Centre of Competence for Climate Impacts”, in cooperation with the Federal Ministry of Education and Research. Furthermore, such initiatives already exist in several federal states. Further organisational and financial support of such networks of actors through public and increasingly also through private sources is desirable, since such networks provide necessary information for vulnerability assessment, as well as communication platforms for coordinated adaptation measures.