Floating Houses and Mosquito Nets: Emerging Climate Change Adaptation Strategies Around the World

Case Studies from Selected Countries

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MEISTER CONSULTANTS GROUP THANKS E.ON KRAFTWERKE FOR GENEROUSLY SUPPORTING THIS STUDY.
Climate Change Adaptation – a new policy area emerges

Dear readers,

We are experiencing the initial impacts of climate change today. The increase in the earth’s average temperature, the decrease in snow and ice cover, the rising sea level, changes in water supply and the loss of biodiversity are effects of climate change that will increasingly impact the future of our planet. While the exact economic and social consequences of extreme weather events like heat waves, droughts, intense rains, storms and flooding cannot be predicted today, natural disasters like Hurricane Katrina in 2005 demonstrate how dramatic the consequences can be if such events occur more frequently.

There is consensus that the effects of climate change have to be kept to a minimum, otherwise the social and economic impacts will not be manageable. In order to prevent dangerous climate change, the global average temperature must not increase by more than 2 degrees Celsius as compared to pre-industrial levels. This goal can only be achieved if all stakeholders implement far-reaching measures. This means that all opportunities for climate protection should be taken, both at the national and at the international level.

However, it is clear today that climate change will continue for the foreseeable future and that adaptation to a changing climate is necessary, if only due to the inertia of the current climate system. The rise in sea level and the regional changes to water resources will have dramatic impacts on people’s lives, especially in developing countries. One result will be an increasing number of climate refugees: millions of people will lose their livelihood due to climate change. For developing countries, climate change is a question of global justice. The facilitation of social and economic development, the prevention of conflicts over scarce resources and the protection of natural resources are key challenges of climate change adaptation. Only if climate change mitigation and adaptation are achieved in parallel will these countries have a chance to achieve sustainable development.

This study analyzes examples of climate change adaptation strategies and measures around the globe and shows how adaptation strategies can be successful. The great variety of examples and the identification of factors for a successful policy are helpful guidelines for all who are active in the climate sector. I wish readers an inspiring reading and may you find many new insights for your work.

Dr. Mojib Latif
Professor and climate scientist at the Leibniz Institute of Marine Sciences at the Christian-Albrechts-University Kiel, Germany (IFM-GEOMAR)
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INTRODUCTION

What Does Adaptation to Climate Change Mean and Why is it Important?

The impacts of global climate change are occurring daily, right before our eyes. The mounting scientific evidence of anthropogenic climate change is difficult, if not impossible, to refute, as evidenced by the fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) of 2007. The climate change crisis has also increasingly emerged as a topic of public concern due to events such as the Wilkins ice shelf collapse, Hurricane Katrina, and the high-profile public awareness campaigns of former US Vice President Al Gore and his resulting Nobel Prize (shared with the authors of the IPCC). The IPCC report summarizes the worldwide research to date on climate change. Among its findings, the authors estimate that millions of people will be affected by floods due to rising sea level, most of them located amidst the mega-deltas of the great rivers of Asia and Africa. Africa alone expects between 75 and 250 million people to be affected by floods and droughts by the year 2020. Climate change amplifies the scarcity of natural resources and thereby aggravates existing problems like erosion and desertification.

Climate change mitigation will remain the central focus of climate policy. However, even if we were able to substantially reduce the level of greenhouse gas emissions immediately, many effects of climate change would still occur. Emissions produced to date have already committed the world to global temperature increases during the next 30 to 40 years and rising sea levels over the next 100 years. Therefore, we need not just to reduce emissions (and mitigate future impacts) but also to prepare for the expected consequences of climate change by developing adaptation measures. Climate change will increasingly affect many fundamental areas of society, including fresh water supplies, agriculture, health, ecosystems, biodiversity, and infrastructure, to name but a few.

While climate change is a global phenomenon, different parts of society and geographic regions will be affected differently and with varying intensity. Two factors will determine the extent to which a given region or community will be affected by the consequences of climate change:

- The natural vulnerability of the region to changes in the climate and extreme weather events.
- The capacity and ability of a given country or community to adapt to these changes.

Due to their geographic location and limited capacities to adapt, climate change represents a serious challenge for developing countries. However, industrialized countries will also have to confront their own significant impacts, ones that will require them to modify behavior and policies accordingly. Furthermore, industrialized countries are faced with mounting domestic and international pressure to contribute to the funding of adaptation measures in developing countries. Representatives of developing countries as well as non-governmental organizations (NGOs) argue that industrialized countries have an obligation to fund international relief and adaptation efforts, especially given their historic responsibility for current emission levels. The challenge of financing climate change adaptation in developing countries will be a key issue at the upcoming Conference in Copenhagen in December 2009.

What Does “Adaptation” Mean?

The Intergovernmental Panel on Climate Change (IPCC) defines adaptation to climate change as follows: “Adaptation: any adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.”

While this definition seems clear, its practical implications are difficult to determine. Are specific adaptation measures merely general measures that would have been implemented anyway? For instance, many measures that are carried out in developing countries are aimed at the sustainable use of natural resources like water and soil. Such measures are required regardless of the level of climate change impacts. Nevertheless, climate change will likely make scarce natural resources still scarcer, so that programs for sustainable resource management also contribute to an overall adaptation strategy. It is not always possible to distinguish between adaptation measures and more general efforts in a certain area.
How Can We Prepare for Climate Change?

Adaptation is not merely an option for countries—rather, it is a requirement. However, specific needs and measures will vary by country and region. Societies will have to consider carefully the effects on urban and land use planning, water management (flood protection and drought), soil (desertification, erosion), infrastructure and transportation planning, energy, agriculture and forestry, healthcare, insurance and finance, construction, disaster control, biodiversity as well as tourism. The following table lists examples of possible adaptation measures.

Sectors that require adaptation to climate change

<table>
<thead>
<tr>
<th>Sectors</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building, Urban and Land Use Planning</td>
<td>Adaptation of urban planning and buildings to changed temperatures and the rising occurrence of extreme weather events (e.g. creation of green spaces in order to cool cities down)</td>
</tr>
<tr>
<td>Water Management (Floods)</td>
<td>Protection against the rising sea level and adaptation to changing patterns of precipitation (e.g. extension of flood protection)</td>
</tr>
<tr>
<td>Water Management (Drought)</td>
<td>Management of declining water resources (e.g. measures to save water, irrigation systems, rainwater collection)</td>
</tr>
<tr>
<td>Soil</td>
<td>Measures to protect soil from negative consequences of climate change (e.g. prevention of desertification and soil erosion)</td>
</tr>
<tr>
<td>Infrastructure and Transport</td>
<td>Adaptation of infrastructure and the transport sector (e.g. incorporating changing water levels in bridge building, improving resilience against weather extremes)</td>
</tr>
<tr>
<td>Energy</td>
<td>Adaptation of energy supply (e.g. preparing the electricity grid for the rising frequency of extreme weather events, taking into account the changing potential of hydropower)</td>
</tr>
<tr>
<td>Agriculture and Forestry</td>
<td>Adaptation of cultivation techniques to changing temperatures and rainfalls (e.g. new, more drought resistant plants)</td>
</tr>
<tr>
<td>Health</td>
<td>Preparation for changing health risks (e.g. dealing with the spread of malaria, thermal stress)</td>
</tr>
<tr>
<td>Insurance and Finance</td>
<td>Dealing with rising climate risks like floods, storms and droughts (e.g. developing innovative microinsurances)</td>
</tr>
<tr>
<td>Disaster Control</td>
<td>Preparing for the rising occurrence of extreme weather events (e.g. improving early warning systems)</td>
</tr>
<tr>
<td>Biodiversity</td>
<td>Protecting biodiversity, which is threatened by changing climate conditions (e.g. protecting endemic species, creating reserves)</td>
</tr>
<tr>
<td>Tourism</td>
<td>Adaptation of tourism concepts (e.g. moving winter sports areas)</td>
</tr>
</tbody>
</table>

Climate Protection and Adaptation to Climate Change: Synergies and Trade-offs

The connection between adaptation and climate protection can be summarized in one sentence: We have to avoid what we cannot handle, and handle what we cannot avoid. The Stern Report of 2006 illustrates the importance of considering the costs of climate change adaptation. Commissioned by the British Government, the Stern Report was the first systematic attempt to estimate the costs of worldwide adaptation measures as compared to mitigation. Stern estimated that the “Business As Usual” scenario would result in
annual costs between five and 20 percent of the global Gross Domestic Product (GDP). It therefore makes good economic sense to invest in climate mitigation now in order to avoid costly adaptation measures later. In order to avoid unbearable costs for citizens and businesses in the coming decades, the countries of the world should make reducing emission levels their first priority. At the same time, the Stern Report also advised protecting society and nature from those consequences of climate change that cannot be avoided. Climate protection and adaptation have to be thought of as two sides of the same coin.

There are measures that contribute both to climate protection and adaptation (win-win measures), but there are also trade-offs between these objectives. One example of a win-win measure would be reforestation. Reforestation can improve protections against the consequences of extreme weather events associated with climate change, especially in developing countries and emerging markets. For example, soil erosion from storms and heavy rainfall is dramatically reduced if the affected areas are reforested. At the same time, reforestation contributes to climate protection as the new plants absorb additional carbon dioxide (CO₂).

An example of a trade-off is the growing use of air conditioning due to higher temperatures. This is an adaptation measure that raises energy use and thereby increases greenhouse gas emissions, at least if the additional energy demand is not met by clean renewable energy sources. Another example involves ski areas. Snow cannons are used to produce artificial snow at many skiing areas that have experienced lower seasonal snowfall due to climate change. This is an adaptation measure, but one that can require additional energy and water use and thereby counteracts climate protection measures.

More and More Countries Want to Adapt to Climate Change; Critics Fall Silent

Our study shows that adaptation to climate change is gaining in political importance. In the international community, the most important issue concerns how necessary adaptation measures will be funded in developing countries. Adaptation was important to the agenda of the UN climate conference in Bali in December, 2007. The challenge of funding climate adaptation measures in developing countries will be a key issue at the climate summit in Copenhagen in 2009, which is dedicated to the creation of a treaty framework for a post-Kyoto future.
More and More Scientists, Media Outlets and Decision-Makers Acknowledge the Importance of Adaptation Measures

“Adaptation is crucial to deal with the unavoidable impacts of climate change.”
Stern Review, Great Britain, 2006

“Over the next decades, it is predicted that billions of people, particularly those in developing countries, will face shortages of water and food and greater risks to health and life as a result of climate change. Concerted global action is needed to enable developing countries to adapt to the effects of climate change that are happening now and will worsen in the future.”
United Nations Framework Convention on Climate Change (UNFCCC), 2008

“… I call on the leaders of the rich world to bring adaptation to climate change to the heart of the international poverty agenda—and to do it now, before it is too late.”
Bishop Desmond Tutu, South Africa, 2007

“Adapting California’s water management systems to climate change presents one of the most significant challenges of the 21st century.”
California Department of Water Resources, 2008

“The seriousness of climate change is becoming greater and more disturbing with each passing year. We must work hard to reduce carbon emissions, but even with the emission reductions we are committed to achieving, some amount of climate change is inevitable. It is therefore essential that we start work now with governments, businesses, and communities to develop a comprehensive adaptation strategy for the EU and to ensure that adaptation is integrated into key EU policies.”
EU Environment Commissioner Stavros Dimas, 2009

Given the massive worldwide impacts that climate change portends, it seems surprising that many countries have only recently started to seriously prepare for the consequences. One explanation for this is the fact that there has been a long-standing debate about whether adaptation to climate change is even possible and whether it makes sense. The most prominent example in this regard has been the position of climate activist and Nobel laureate Al Gore. Gore considered it to be presumptuous to believe that mankind could ever prepare for the fundamental changes associated with global warming. Furthermore, he feared that the debate about adaptation measures would distract from needed climate protection efforts. Other critics argued in a similar way: if we believe that we can adapt to climate change, we will not care about preserving the current climate anymore. However, given the massive impacts that cannot be avoided even if our emissions are completely eliminated, adaptation measures will still be necessary. As such, Gore has revised his position. He now advocates that industrialized countries should actively support developing countries in adaptation. Overall, the fundamental critique of adaptation measures has been eclipsed. The new consensus is that both adaptation and climate protection are indispensable.

Al Gore: From a Critic to a Supporter of Adaptation Measures

Al Gore 1992: Adaptation is “a kind of laziness, an arrogant faith in our ability to react in time to save our skins.”

Al Gore 2007: “We really have to focus on prevention.”

Al Gore 2008: “I used to think adaptation subtracted from our efforts on prevention. But I’ve changed my mind… Poor countries are vulnerable and need our help.”
The Approach of the Study

This study offers the first overview of the adaptation strategies and measures of industrialized, emerging markets, and developing countries, based on 16 individual country case studies. The main research objective is to determine how each of the countries study and prepare for the impacts of climate change. The focus of the study is on national adaptation strategies; however, depending on the situation of the respective countries, regional and local level initiatives are analyzed as well. From this analysis, the study reveals those factors necessary for the successful development and implementation of adaptation strategies. These factors provide a first step for policymakers in this emerging policy field.

The study intends to provide a starting point for policymakers who are confronted with climate change adaptation. Therefore, it includes a collection of specific project examples in addition to the country case studies. The aim of those examples is to show how climate change adaptation can be implemented at the ground level.4

Focus

This study focuses on adaptation measures, as until now adaptation strategies have received far less attention than climate protection. This is in spite of the fact that adapting to the unavoidable impacts of climate change will present a serious challenge well into the future. This does not imply in any way that adaptation measures are more important than climate protection measures. To the contrary, without massive efforts to protect the climate in the present, adaptation to global warming will not be feasible in the future. The consequences will simply be too severe.

Contents

The study focuses on the analysis of national adaptation strategies. We assume adaptation is a political as well as logistical challenge, and that a coordinated approach is crucial to tackle the consequences of climate change. Depending on the structure of the respective country, regional and local strategies will be outlined as well. For example, the United States section places a greater emphasis on individual state strategies. States are already working on adaptation strategies, but nothing similar can be observed on the federal level. In countries that already have a national adaptation strategy, greater emphasis is put on the national level.

The collection of project case studies in the appendix offers an overview of specific adaptation measures which have already been initiated or implemented. In this section, the focus is on local and regional projects, because all concrete adaptation measures must be implemented at the local level. The regional and local impacts of climate change can vary significantly, which suggests that every city and municipality should have its own planning process. We do not claim that this collection of project case studies presents the best adaptation projects worldwide; rather, this collection is intended to illustrate the range of possible measures, and to highlight promising ideas and approaches.

The study is based on literature and internet research, as well as on interviews with academics, policy experts, and representatives of non-governmental organizations.

Selection of Countries

The study includes industrialized, emerging markets, and developing countries. Developing countries and emerging markets face the most serious consequences of climate change. They are particularly vulnerable, because their populations and economies typically rely heavily on natural resources (e.g., agriculture). At the same time, their capacity to adapt is limited. However, the impacts of climate change also present important challenges to industrialized countries. In temperate regions, where many industrialized countries are located, temperature rises are expected to be above average. In addition, given their greater technical, economic and institutional capacity, these countries can make important contributions to adaptation policy in general.

The study used two criteria to determine the selection of countries:

- The selected countries should already have in place national and regional efforts to adapt to the impacts of climate change.
- The selected countries should illustrate how different sectors of society are affected by climate change, as well as how different regions will respond to different climatic conditions. In this way, the study can illustrate the broad range of needed adaptation measures.

Finally, given their importance in the international climate debate, both India and China are covered, along with exam-
Examples of Least Developed Countries like Tanzania and Bangladesh.

Results
Due to the global scope of the selected countries, it is not possible to compare individual countries directly. Rather, it is the emerging understanding of adaptation policy across various industrialized, emerging markets and developing countries that is instructive. Despite individual differences, this survey allows important similarities to be identified with regard to adaptation policies. The study shows how 16 different countries are already planning and implementing measures to prepare for the consequences of climate change. The country chapters offer an overall picture of the current adaptation policy in each respective country.

Given the complexity of the issue, not all aspects of adaptation can be covered within the limited scope of this study. The study, therefore, is not a comprehensive scientific analysis, but is instead a description of instructive approaches for each of the respective countries.

This study identifies certain universal success factors. The worldwide analysis shows that promising adaptation approaches can be found in industrialized, emerging markets, and developing countries. Hence, the study does not represent a comprehensive scientific analysis, but rather a presentation of interesting and instructive approaches utilized in the selected countries.

Some countries are more advanced with regard to the development of a comprehensive adaptation strategy, while other countries have sector-specific strategies, for instance in the case of disaster control. The country assessments found in this report do not serve as a ranking. Since the topic is complex and the related research is still in its infancy, it would not be sensible to rank countries at this point. In contrast to climate protection, where success can be measured by CO₂ emissions rates, there is no such system of indicators that can measure progress with respect to adaptation. In many countries adaptation involves a wide range of policy areas that need to be assessed individually. Additionally, the consequences of climate change will only become apparent in the upcoming years and decades, meaning that the success of different adaptation strategies can only be evaluated over time.

Structure of the Country Chapters
The individual country case studies comprise a central part of the study, as do the collection of concrete adaptation projects in each country. While each chapter on a featured country uses the same overall structure, the focus of each depends on the country’s respective situation and reflects the significant differences between the countries in the survey.

The following structure was used for the country chapters:

Summary
First, the central findings for each country are briefly summarized.

Country Profile
Subsequently, the impacts of climate change in the respective country are described. Because many impacts (like the increase of extreme weather events) affect almost all countries and do not have to be repeated in each chapter, the focus will be on impacts that are relevant for the respective country. The goal is to provide an illustrative impression of risks and opportunities in each of the countries profiled. Without this information, the specific adaptation policies cannot be readily understood. This section does not try to incorporate the most recent scientific research. The value of the study consists of an overview of adaptation strategies and measures in each of the respective countries.

Strategies and Actors
This section presents an overview of the existing adaptation strategies and measures as well the most relevant actors in the country. The focus is on the national level, but regional and local programs are considered as well, especially in countries that have not yet developed national strategies. For instance, in the US, the federal government has not adopted any adaptation plan to date, which is why the adaptation measures taken by California and Alaska are presented as an illustration of state-based strategies.

Information, Communication and Education
Countries can only be in a position to develop effective adaptation measures if they have sound data on specific local impacts of climate change. At the same time, many different actors must be involved in the implementation of adaptation measures, and these actors have to be informed about the impacts of climate change. Therefore, a separate section covers the issue of information and communication.
Adapting to the impacts of climate change presents a **long-term challenge** to the global community across all sectors. Climate change is a truly global phenomenon that requires a variety of specific strategies and responses. As with the challenge of demographic change in Europe and Japan, regions which face an aging population coupled with low fertility rates, climate adaptation challenges have been underestimated for far too long. Analysis of case studies of countries from around the world revealed five common characteristics inherent to the process of adapting to climate change. These case studies show that adaptation initiatives share the following characteristics:

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**Characteristics of Adaptation Policy**

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<td>5</td>
<td>Local Implementation amidst a Global Context</td>
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1. **Cross-Cutting Approach**
   Adaptation to climate change requires a cross-cutting approach that affects a variety of policy areas. The specific climatic conditions (e.g., drought and the protection of biodiversity in South Africa and Australia, or dealing with melting permafrost in Canada and Switzerland), as well as the socioeconomic profile of a country, determine the importance of various policy areas. While comprehensive national strategies have emerged only recently, sector-specific strategies and plans (e.g., flood prevention in the Netherlands or disaster control in Bangladesh) already incorporate strategies that deal with the impacts of climate change.

2. **Diversity of Actors**
   Adapting to climate change requires the involvement of many different actors. The challenge affects almost all areas of government and policy, ranging from departments of health to departments of foreign affairs. It concerns political as well as administrative units on all levels, from the international to the local. For example, while funding adaptation measures in developing countries is part of international climate negotiations, adjusting urban design to rising temperatures is a matter left to local planning and policymakers. Furthermore, representatives of academia, business and NGOs, as well the general public, must be involved in preparing for a changing climate. Academia has to provide the needed expertise; businesses and NGOs have to provide innovative solutions for the upcoming challenges; and the general public has to be informed in order to mobilize citizens for the required behavioral changes and to be aware of imminent dangers. Given this diversity of actors, conflicts of interest and diverging expectations should be expected. Therefore, the involvement and coordination of all relevant actors is of pivotal importance.

3. **Long-term Perspective**
   Climate adaptation measures have even greater long-term implications than the challenges surrounding demographic changes. Even if global emissions of CO₂ could be reduced to zero immediately, temperatures will continue to increase for at least the next 30 to 40 years, and sea level will rise for the next 100 years. This makes the policy planning process especially challenging. Despite the long-term horizon, it is crucial to generate sufficient political will and public awareness in order to place climate change high enough on the political agenda today. The delayed reaction to demographic changes in Europe serves as an example of how hesitation and delay can raise the costs of adaptation measures substantially.
4. Acting under Uncertainty

Communicating information and analysis are critical aspects of climate change adaptation strategies. Decision-makers have to be provided with the latest scientific climate scenarios, and the general public needs to be informed about the implications of climate change on their lives and livelihoods. Planning long-term adaptation measures without solid data is not feasible. Despite advances in research, and an emerging scientific consensus on climate change, adaptation policies will always have to deal with a certain level of uncertainty. For instance, projections changes in regional patterns of precipitation have wide ranges of uncertainty. Given the complexity and the dynamic nature of global climate systems, we will have to cope with unexpected changes that cannot be predicted today. This requires a more nuanced strategic planning process that goes beyond a simple analysis of data and facts. It involves scenario planning, a search for the right levers, as well a concerted attempt to minimize the likelihood of worst case scenarios.

5. Local Implementation amidst a Global Context

While climate protection efforts at the local level have global impacts, the converse is true when considering the consequences to local communities affected by global processes. These impacts vary significantly by country and region. Therefore, national as well as regional and local decision-makers must be at the forefront in crafting climate change adaptation strategies. At the same time, the international community as a whole is faced with funding adaptation measures and making provisions for technical assistance at the regional and local level. This is particularly true for developing countries.

Building on these five characteristics one can derive ten keys to success when developing adaptation strategies:

### Ten Keys to Success for Adaptation Strategies

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Success Factors</th>
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</thead>
<tbody>
<tr>
<td>Cross-Cutting Approach</td>
<td>1. Mainstreaming; Integrating adaptation in all relevant planning processes and development strategies</td>
</tr>
<tr>
<td></td>
<td>2. Institutionalizing adaptation as a policy and practice across different government departments and functions</td>
</tr>
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<td></td>
<td>3. Creating links with existing strategies, structures and goals (e.g. sustainability, poverty reduction)</td>
</tr>
<tr>
<td>Diversity of Actors</td>
<td>4. Systematic involvement of all relevant stakeholders</td>
</tr>
<tr>
<td>Long-term Perspective</td>
<td>5. Establishing continuity in planning and implementation processes as well as regular progress reviews of strategies and measures</td>
</tr>
<tr>
<td>Acting under Uncertainty</td>
<td>6. Gathering sound data for strategic planning</td>
</tr>
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<td></td>
<td>7. Facilitating dialogue and cooperation between academic researchers and policymakers to ensure science is relevant to the policy-making process</td>
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<tr>
<td></td>
<td>8. Focusing on no regret and/or low regret measures</td>
</tr>
<tr>
<td>Local implementation amidst a Global Context</td>
<td>9. Providing support for local communities as many measures have to be implemented at the local level</td>
</tr>
<tr>
<td></td>
<td>10. Recognizing and benefiting from the international nature of adaptation policies (e.g. funding, exchange of best practices)</td>
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</table>
Floating Houses and Mosquito Nets:

1. **“Mainstreaming”**: The projected consequences of climate change as well as the needed adaptation measures should be systematically integrated into all relevant planning and development strategies. For instance, the need for adaptation has to be considered in the cases of land use planning (e.g., bridge building), as well public health emergency plans (e.g., heat waves). It is crucial to set the right priorities while not ignoring any important aspects. For example, in Great Britain the rules for environmental impact assessment (of laws and regulations) are reviewed in order to make sure that the consequences of climate change are sufficiently factored into the policy planning process. Finland requires that climate change be considered systematically in strategic planning processes.

2. **Adaptation** as a policy and practice needs to be institutionalized across different government departments and functions. Governance structures across units, sectors and levels have to be organized to address cross-cutting challenges in a coordinated manner. Government officials need to cooperate across different branches, ministries and departments. At the same time a variety of actors from the business community, academia and society need to be involved. The institutional context is an important success factor both on the national as well as regional and local levels. For example, the British government created a framework that involves a great number of ministries and institutions in order to address adaptation issues in a coordinated manner.

3. Adaptation to climate change should be **linked with existing strategies, structures and goals** (e.g., sustainability, poverty reduction) to avoid duplicated efforts. These coordination efforts will vary from country to country. For instance, if a country has an effective sustainability planning process or a successful biodiversity strategy, adaptation measures can be integrated with these efforts. A country might also be particularly affected by a certain challenge (as in the case of flood protection in the Netherlands or Bangladesh). In such cases it makes sense to connect the adaptation strategy to the existing planning process.

4. Besides the coordination of political actors, **all relevant stakeholders should be systematically involved** in order to ensure that adaptation measures have a broad support base. Many industrialized countries have developed their strategies together with stakeholders from academia. In developing countries those groups that are most directly affected by the consequences of climate change (e.g., fishermen or farmers) are most often involved. This is partly because there is a considerable lack of reliable data in many developing countries (especially in Africa), which tends to mean that adaptation measures are prioritized according to local reports on the observable effects of climate change. However, if possible the general public should be involved as well. For example, in Bangladesh, participatory approaches to disaster control have been successfully implemented at the local level. The population is actively involved in early warning systems. In the Netherlands, the public has been informed about the consequences of climate change through the campaign Room for the River.

5. Another success factor for adaptation programs is **continuity** in the planning and implementation process, as along with **continual progress assessments** of the strategies and measures employed. At this point, it is too early to evaluate the continuity of adaptation efforts in the countries we studied. Nevertheless, some countries have already updated provisions of their adaptation strategies. The United Kingdom plans to pass legislation that makes strategy updates mandatory. The Finnish strategy is supposed to be evaluated and updated every six to eight years. In order to realize these plans on a regular basis, political and public awareness have to be mobilized.
6. An important condition for sound adaptation policy is the gathering of sound data to document and track the concrete impacts of climate change. Today, most industrialized countries collect reasonably good data that enables comprehensive scenario planning. Many developing countries are only beginning to collect such data. Especially in sub-Saharan Africa, the data can be very limited; in some regions the quality of the data has even been declining in recent years. An important exception is South Africa, which possesses very good climate data. The lack of reliable data has led many developing countries to resort to the temporary solution of using informal observations by the local population about impacts to develop adaptation strategies. While every country should involve its local population in the adaptation process, the process alone cannot offset the lack of reliable data. Data from individual observations might help developing countries to find short-term solutions to immediate threats, but this approach is not sufficient to develop long-term strategies against major impacts of climate change.

7. In order to use the relevant climate data effectively in the policy planning process, there needs to be cooperation between academic researchers and policy-makers. Predicting changes in the climate is a highly complex endeavour, and therefore, policy-makers need data, results, and analysis to be presented as clearly as possible. Researchers need to adjust their communication strategies to be sure their messages reach policy-makers. The exchange between researchers and policy-makers has to be fostered to raise the awareness among political decision-makers regarding the importance of sound data for the quality of their work. In Great Britain, the UK Climate Impact Programme is a good example of this important function.

8. Even if sufficient data are available, there is uncertainty associated with predictions about the exact impacts of climate change in different sectors. Much depends on future emission levels. Policy-makers should therefore focus their adaptation efforts on “no regret” and/or “low regret” measures if possible. Such measures yield positive results even if the local impacts of climate change are greater or weaker than projected. Many countries already emphasize the importance of these “no regret” and “low regret” measures within their adaptation strategies. For example, a “low regret” measure would be the construction of a new dam against flooding, which does not offer sufficient protection against high sea level rise. This facility can be designed in such a way that allows for its expansion at a later date at relatively low costs, if necessary. Likewise, an example of a “no regret” measure would be an initiative that requires or promotes sustainable extraction of natural resources. In India, for example, sustainable development is regarded as part of the process of adapting to climate change. Hence, “no regret” measures are wise under any climate scenario. The “win-win” measures cited above also belong to this category.

9. Support for local communities is indispensable, given that many measures have to be implemented locally. In Great Britain, a variety of specific information and support tools are available for local decision-makers. In the US and Australia, handbooks on adaptation strategies for municipalities have been published.

10. Finally, it is also important to be aware of the international nature and dimension of the issue. Finland makes explicit reference to the global perspective in its national adaptation strategy, and the Ministry of Foreign Affairs is involved in the implementation of the adaptation strategy as one of six ministries in a cross-departmental task force. In Great Britain, the Ministry of Defense is working on a strategy that recognizes the interdependence of climate change and national security.
How the Studied Countries Prepare for the Impacts of Climate Change.

More and more countries have begun to address the consequences of climate change. To date, many of them have passed national strategies, but most are still just beginning to develop strategies and deciding how to implement them. However, in countries where climate change threatens to aggravate long-standing problems, comprehensive strategies and specific measures are already being developed. For instance, the Netherlands has a flood protection strategy, while Bangladesh has a strategy to respond to natural disasters.

Least Developed Countries (LDCs) represent a special case. These countries are supported in their efforts to develop national adaptation strategies by the UNFCCC’s National Adaptation Programmes of Action (NAPAs). Thanks to these programs, 42 out of 49 LDCs now have national adaptation strategies. However, this does not imply that these countries are well prepared for the impacts of climate change. NAPAs mainly focus on short-term measures, and the financial resources available for their implementation are typically very limited. In this study, Tanzania and Bangladesh serve as case studies for the specific challenges LDCs face.

Furthermore, there are countries that are not active on the national level where individual regions are preparing themselves for the impacts of climate change. The US is a good example in this regard. Some individual states are already developing adaptation measures, though the federal government has so far not taken action.

Each country’s adaptation strategy can be summarized as follows:

<table>
<thead>
<tr>
<th>Country</th>
<th>Summary</th>
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<tbody>
<tr>
<td>Finland</td>
<td>While climate change represents a threat for most countries, Finland is expected to experience both risks and opportunities. Finnish economic sectors that are affected include transportation, tourism, agriculture, forestry and energy. Finland developed a comprehensive adaptation strategy in 2005, making it one of the first countries to have a comprehensive adaptation strategy in place. The Ministry for Agriculture and Forestry leads the effort, while a task force integrates five additional ministries in the planning process. Compared to other countries, the need for action in Finland is limited to a small number of areas, because the short-term consequences of climate change do not present a threat to the Nordic country. Consequently, the Finnish adaptation activities focus on research and analysis, to develop a better understanding of the opportunities and risks in relevant sectors. However, in some areas concrete measures have already been implemented, especially in the case of flood protection.</td>
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<tr>
<td>France</td>
<td>In the last few years, an increase in the frequency and intensity of extreme weather has raised public awareness about need for adaptation. The heat wave of 2003 and the long periods of drought experienced in the south of the country have contributed to the view that France needs to intensify its efforts to prepare for the impacts of climate change. In response, France passed a national adaptation strategy at the end of 2006. Currently, the development of a detailed adaptation plan is under consideration,</td>
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</table>
Emerging Climate Change Adaptation Strategies Around the World

with the research institution ONERC leading the strategic planning process. The national adaptation strategy emphasizes the importance of analyzing the consequences of climate change and risk assessment. There are numerous research programs that aim to provide the needed data for further strategic planning. In France, great weight is attached to economic and social aspects of adaptation. However, the implementation of concrete measures has been limited to singular cases. For example, Paris has taken precautions to be better prepared for future heat waves.

<p>| Germany | In December 2008, the German government passed a national adaptation strategy. This strategy is intended to be a framework for the development of adaptation measures on the national, regional and local level, as well as for adaptation measures to be taken by companies, associations and citizens. The strategy will be implemented in a step-by-step process. Important steps include the further improvement of the knowledge base, the start of a broad dialogue and communication process, and the development of a concrete action plan by March 2011. The German strategy describes 13 focus areas where regional and spatial planning and emergency management are defined as cross-cutting issues. Individual German states (Bundesländer) are also starting to prepare for the impacts of climate change, and some have developed their own adaptation strategies and plans. |
| Great Britain | Great Britain is at the vanguard of climate change adaptation. The country follows a coordinated approach that covers almost all policy areas and involves all key actors, ranging from the Ministry of Environment to the Ministry of Defense. The strategy focuses on integrating adaptation policy into the general political process. For instance, adaptation figures into the government investment process and in the evaluation of municipalities. An important success factor for the British adaptation strategy was the early establishment of an information and coordination center that brings together academia and policy-makers. For example, municipalities are provided with analysis and assessment tools that help them estimate the risk of climate change and plan the appropriate adaptation measures. Great Britain is more active than many other countries in communicating the need to adapt to climate change. The consequences of climate change in the Great Britain include the risk of flooding, as along with erosion along the coast line and river basins. |
| Netherlands | A significant part of the Netherlands is situated below sea level. In order to prevent catastrophes like the Storm Tide of 1953, adaptation to climate change is regarded as a matter of national security. Rising sea levels will result in an increased likelihood of flooding. The issue has been on the political agenda for many years, especially in the context of water management, coastal protection, and land use planning. In light of the fact that a rise in sea level is unavoidable, the approach to flood prevention has evolved from fighting against the rising tide to living with and adapting to it. In 2007, the Netherlands enacted its national program for adaptation. Furthermore, the &quot;Delta Commission&quot; was also established in 2007 in order to develop a flood prevention strategy. The commission published its recommendations at the end of 2008. A law that deals with flood prevention is currently pending. |
| Spain | In Spain, climate change will most likely lead to water scarcity and rising temperatures. The Ministry of the Environment led published a national adaptation plan in 2006. The plan was intended to improve the coordination and integration of the climate adaptation measures. In addition to action at the national level, many nongovernmental organizations, municipal governments and individual companies have implemented adaptation measures. Addressing water scarcity is especially important, and the country has already adopted an action plan to combat desertification. |</p>
<table>
<thead>
<tr>
<th>Country</th>
<th>Description</th>
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<tbody>
<tr>
<td>Switzerland</td>
<td>As in other countries, climate change will lead to extreme weather phenomena in Switzerland, as well as to fundamental changes in the economic and living conditions in the country. Switzerland can serve as a role model with regard to its response to extreme weather phenomena. This is mainly because climate change aggravates challenges associated with Switzerland’s alpine geography; responding to these challenges have always been on the political agenda. During the last few years, Switzerland has shifted its focus from disaster management to preventative measures. Even so, Switzerland is only beginning to develop a comprehensive strategy for adaptation to climate change.</td>
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<tr>
<td>Canada</td>
<td>Canada is expected to experience changes to its climate that present both risks and economic opportunities. Because of the country’s sheer size and geographic diversity, the impacts vary significantly by region. The arctic regions especially are already affected by climate change, and where local populations depend on natural resources, their livelihoods are already threatened. However, it is also in these same areas where economic opportunities are emerging due to climate change. For instance, with the rising ocean temperatures, new waterways along the Northwest passage will be accessible, and new natural resources will become available. Adaptation to climate change has been on the agenda of the Canadian government for some time. Nonetheless, most of the specific measures have been developed and implemented by individual provinces or various municipalities.</td>
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<tr>
<td>USA</td>
<td>The US does not yet have a national adaptation strategy. However, adaptation to climate change has been part of the discussion on the climate protection legislation currently being debated in Congress. Some states are more advanced, with Alaska, California, and Florida being the early pioneers in this field. For instance, California is currently in the process of developing a comprehensive adaptation strategy, and it has already implemented adaptation measures with regard to water management. Alaska also faces the consequences of climate change, and is working on an adaptation strategy.</td>
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<tr>
<td>Australia</td>
<td>One of the major challenges facing Australia is the rising number of droughts, which affect agriculture as well as the unique biodiversity of the country. Australia’s vulnerability to the consequences of climate change was exposed when dramatic droughts in 2002 and 2003 hit large parts of the country. In response, the Australian government passed a National Climate Change Adaptation Framework in 2007. The framework includes a range of concrete measures, including training programs for those occupational groups most affected by climate change. The individual Australian states have also started to prepare for climate change.</td>
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<tr>
<td>South Africa</td>
<td>South Africa faces serious challenges associated with climate change. Water scarcity is already very high on the political agenda, and climate change will further aggravate the water situation. Other important challenges include health effects. Biodiversity loss will be especially economically important, given some of the country’s unique natural habitats and their relevance to the tourism industry. South Africa is better prepared to deal with the consequences of climate change than many other African countries because of the availability of more reliable climate data and projections than other African states. Since 2004, South Africa has had a national climate strategy that addresses the need for adaptation. A more detailed adaptation policy is currently under preparation and is expected to be released in 2010.</td>
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<tr>
<td>Tanzania</td>
<td>As one of the least developed countries in the world, Tanzania is especially vulnerable to the consequences of climate change. More than half of the country lives on less than a dollar per day, and more than 80 percent depend on subsistence agriculture and therefore, on natural resources. Given its geo-</td>
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</table>
graphic conditions, the impacts of climate change in Tanzania are very diverse. Affected sectors include agriculture, water management, public health, biodiversity and energy. Tanzania has developed a national adaptation plan, but the proposed measures are not sufficient to deal with the challenge of climate change. The plan emphasizes only the most urgent short-term measures, and the implementation process is just beginning. This situation is characteristic of many developing countries.

Bangladesh

Bangladesh is one of the countries that will be most affected by climate change. Two thirds of the country is located in low lying coastal wetlands less than five meters above sea level, so rising sea levels pose an especially serious threat. In the past, Bangladesh has frequently been hit by natural disasters, and climate change threatens to make such catastrophes even more common. Despite its financial constraints, the country is trying to prepare for these enormous threats as much as possible in order to minimize the number of potential victims and economic impacts. In this regard, Bangladesh’s case offers some best practices. For instance, in the event of an imminent flood the population is alerted through an early warning system that uses volunteers to alert people via megaphones as well as over the radio. Given the massive threats and its limited financial means, Bangladesh depends on international support for its measures to adapt to climate change.

India

Despite dramatic economic growth over the last decade in India, most of the population still depends to a great extent on agriculture. This makes the country highly vulnerable to the impacts of climate change, which will only further aggravate the pressure put on natural resources. In addition, fresh water supplies are especially at risk. In the context of these threats, the government began to address the potential impacts of climate change and appropriate adaptation measures. Numerous research programs have been launched and some concrete adaptation projects have already been implemented. Furthermore, adaptation measures have been gradually integrated into the overall planning process. In June 2008, the Climate Council of the Prime Minister passed the National Action Plan on Climate Change (NAPCC), which outlines the major threats for India and proposes an adaptation strategy with concrete measures. The respective ministries have been tasked with working out the details.

China

In China agriculture and the water supply will be particularly affected by climate change. Water will probably become scarce in many parts of the country, threatening rural and subsistence agricultural production. In addition, most of China’s big cities and economic centers are located along the coast, and are therefore threatened by rising sea levels. The most recent national climate program from 2007 addressed needed adaptation measures. Additionally, a white paper on climate change was published in October 2008, outlining concrete goals for adaptation measures that must be met by 2010. Besides important infrastructure projects proposed for the water sector, the white paper also announced a redoubling of efforts to protect the environment. These developments show that adaptation has gained in importance amidst the Chinese political agenda.

Brazil

The rain forest in Brazil is a unique ecosystem that is particularly threatened by the impacts of climate change. In the worst case scenario, huge parts of the Amazon River basin could transform into a savannah. This would have dramatic consequences both for the worldwide climate, as well as the local population whose livelihood depends on the rain forest. Like many other Latin American countries, Brazil has not fully confronted what is entailed in adapting to climate change. However, this is gradually changing. For instance, the Brazilian climate change plan published in December 2008 covers adaptation. Based on more accurate regional climate models that are expected to be published in 2009, the government intends to prepare detailed adaptation measures.
THE INDUSTRIALIZED COUNTRIES

AUSTRALIA, BANGLADESH, CANADA, CHINA, GERMANY, GREAT BRITAIN, NETHERLANDS, SOUTH AFRICA, SWITZERLAND, TANZANIA.
Floating Houses and Mosquito Nets:

**Vulnerability – Unequal Distribution of Adaptation Costs and Adaptation Capabilities**

Due to their historically high emission levels, industrialized countries have a greater responsibility for climate change than developing nations. Developing countries suffer most from the consequences of global climate change, while having very limited capacities to deal with the damages caused by droughts, famine and rising sea levels. However, climate change will also present ongoing challenges for industrialized countries during the upcoming decades.

It remains difficult to predict the costs of needed adaptation measures, but they will be considerable. According to preliminary estimates, the adaptation of infrastructure alone in the Organization for Economic Cooperation and Development (OECD) countries could cost between 15 and 150 billion US dollars annually. This represents between 0.05 and 0.5 percent of the countries’ GDP.

The impacts of climate change differ substantially between regions. For example, flooding represents an important challenge in the Netherlands, given that many coastal regions are situated at or below sea level. The increasing frequency of heavy rainfalls, as well as the continuous rise of sea level, requires adaptation measures that deal with flood protection and land use planning. In contrast, Australia is threatened by increasing water shortages. By 2030, the frequency of droughts is expected to rise by 20 percent. Therefore, an important part of the Australian adaptation strategy is to measure water use and to promote the more efficient use of water resources.

While most industrialized states focus on the negative impacts of climate change, some northern countries like Finland and Canada are expected to see some benefit from climate change. For instance, Finland expects an increase in regional opportunities for transportation, tourism, forestry and energy. In Canada, access to natural resources could be facilitated and new arctic water ways could become accessible.

**Adaptation Policy**

In recent years, industrialized countries have developed a much better understanding of the impacts of climate change, though there are still many areas of needed research. Compared to developing countries, industrialized countries will be in a much better position to adapt to climate change due to their greater technical and financial capacities. Even if adaptation solutions developed in industrialized countries cannot be directly transferred to developing countries, the latter can nonetheless benefit from the knowledge and experience generated by such projects.

Industrialized countries are still in an early stage of adaptation; however, many have developed national adaptation strategies or implemented adaptation policies for particularly affected sectors. For example, Great Britain has developed a comprehensive strategy, while the Netherlands has a strong focus on flood protection. Finland passed an adaptation strategy in 2005, making it one of the first countries in the world to do so. France has published numerous studies on the relation between heat and health, and a comprehensive national adaptation strategy was presented in 2006. In the US, the states of California and Alaska are considering the consequences of climate change.

**Adaptation to Climate Change on the EU level**

The EU Commission is also developing detailed strategies to deal with the effects of climate change. In April 2009, the Commission presented a white paper on adaptation strategies. The impacts of climate change differ significantly from region and region, and therefore most specific adaptation measures must be implemented by individual member states and regions. The Commission focuses on coordination and exchange among each of the member states, especially with regard to cross-border tasks and policy areas regulated at the EU level. Furthermore, the Commission aims to integrate adaptation to climate change policy into overall EU foreign policy in order to assist developing countries that are most affected by climate change.

The first phase of the EU adaptation strategy, which runs until 2012, is intended to build a foundation for a more comprehensive adaptation strategy. The EU commission will first establish an adaptation steering committee consisting of representatives from each of the EU member states who are dealing with adaptation to climate change. The steering committee is tasked with contributing to national and regional adaptation programs, as well as with involving academia and the public. Additionally, the EU commission will
further the transfer of knowledge on the impacts of climate change by establishing a mechanism for the exchange of information among member states.

In addition to the white paper, the Commission prepared three discussion papers which deal with needed adaptation strategies for water supply, coastal and marine areas, agriculture, and public health. The EU Commission also funds research projects in order to fill knowledge gaps with regard to the consequences of climate change and appropriate adaptation measures.8
Floating Houses and Mosquito Nets:

Country Profile
The impacts of climate change in Finland will most likely include a reduction of snow cover, melting permafrost, stronger rainfalls, and overall higher temperatures. Additionally, the probability of extreme weather events is projected to increase. The sectors of the Finnish economy most likely to be affected include agriculture and forestry, tourism, transportation, and energy. In these sectors, climate change poses both positive and negative impacts.

Forestry is very important in Finland; three-fourths of the country is covered by forests. Forestry and the wood processing industry are the most important sectors of the Finnish economy. Climate change has the potential to raise productivity of the forestry industry, because increased CO₂ concentrations and higher average annual temperatures can increase the growth rate of forests. However, lower ground stability (caused by reduced snow cover and melting permafrost) along with a higher frequency of insect infestation can lower overall forest productivity.

Agricultural productivity has seen a rise from climate change as well. Potential crop yield is expected to further increase (especially in the case of wheat and potatoes), in part from the increase availability of arable land due to rising temperatures. According to scientific estimates, for every temperature increase of 1 °C, arable agricultural zones can move by about 120 to 150 kilometers to the north.

The impacts of climate change on the Finnish tourism industry differ significantly from region to region. While winter tourism will likely suffer due to reduced snow cover, the south, coastal, and lake regions could expect more tourists during the summer season due to rising temperatures.

In the energy sector, positive consequences could result from falling energy demand due to falling heating output. Furthermore, the potential of hydropower increases as the water inflow becomes more stable during the winter due to glacial melt and runoff. In addition, the production of alternative energy from biomass is expected to rise.

Impacts will also apply to the Finnish transport sector. Shipping is especially important for the Finnish export industry. Lower levels of glaciation have the potential to increase the capacity of ports to accept and ship cargo. However, the increasing threat of floods presents a risk for the transportation system and infrastructure. Additionally, the risk of intense rainfalls could pose additional problems for infrastructure and buildings.

Strategy and Actors
Finland was one of the first countries in the world to develop a climate change adaptation strategy. Strategic planning began back in 2001. Formal work on the adaptation strategy started at end of 2003 following a directive of Parliament. The Ministry for Agriculture and Forestry took responsibility for the process, and other ministries were involved as well.

Summary
While climate change represents a threat for most countries, Finland is expected to experience both risks and opportunities. Economic sectors that are affected include transportation, tourism, agriculture, forestry and energy. Finland was one of the first countries to have a comprehensive adaptation strategy in place since 2005. The ministry for agriculture and forestry leads the effort, while a task force integrates five additional ministries in the planning process. Compared to other countries the need for action in Finland is limited to a small number of areas, as the short-term consequences of climate change do not present a threat to the Nordic country. Consequently, the Finnish adaptation activities are focused on research and analysis in order to develop a better understanding of the opportunities and risks in relevant sectors. However, in some areas concrete measures have already been implemented, especially in the case of flood protection.
Consultations with experts, stakeholders and citizens followed.

In 2005, the adaptation strategy was passed. Central elements of the adaptation strategy were later incorporated in the National Energy and Climate Strategy, which integrates climate protection and adaptation.11

The goal of the Finnish strategy is to enhance the capacity of the Finnish people to adapt to climate change. For Finland, adaptation implies both preventing negative impacts as well as seizing opportunities. The time horizon of the strategy extends to 2080. The strategic plan incorporates immediate implementation actions (from 2005 to 2010), "short-term measures" (from 2010 to 2030) as well as medium- and long-term measures (from 2030 to 2080). Every six to eight years the strategy is to be reviewed in order to incorporate new insights as well as more exact projections about the consequences of climate change in Finland.12

The overall priorities of the Finnish adaptation strategy are:
- Incorporation of the consequences of climate change into the political planning process ("mainstreaming") as well as cooperation across sectors
- Improving preparations for extreme weather events
- Improving flood and sea level control systems
- Strengthening research and development
- Considering the international dimension of climate impacts as well as cooperation with international development goals
- Developing monitoring and warning systems in cooperation with international partners

The adaptation strategy analyzes the expected impacts of climate change in Finland and presents needed adaptation measures in prioritized sectors. The affected sectors include: natural resources (agriculture and food production, forestry, fishery, reindeer rearing, hunting, and water resources), biodiversity, industry, energy, transportation and communication, land use, building, public health, tourism and recreation, and the insurance industry.

The adaptation strategy is coordinated by the Ministry of Agriculture and Forestry in cooperation with five other ministries (Transport and Communication, Trade and Industry, Social Affairs and Health, Environment, and Foreign Affairs), and two research institutions (Finnish Meteorological Institute, FMI, and Finnish Environment Institute, FEI). Additionally, there is a working group within the Ministry for Trade and Energy tasked with coordinating the adaptation strategy with the national energy and climate strategy.

The implementation of the adaptation plan is organized by sectors. Some ministries, such as the Ministry for the Environment, the Ministry for Agriculture and Forestry and the Ministry for Transport and Communication, have developed their own specific strategies as well as implementation plans. Examples are the national forestry program, along with case studies on the needed adaptation in the transport sector. Concrete adaptation projects are already being implemented on the regional and local level, for instance in the case of flood protection.13

Information
The Finnish adaptation strategy was developed in close cooperation with the research community. The research project FINSKEN is especially relevant in this regard. It was intended to deepen the understanding of the impacts of climate change as well as the capacity of Finland to adapt.

An important part of the Finnish strategy is the promotion of research and development in the field of adaptation. This includes both cross-sector and sector-specific studies. In 2006, the Ministry for Agriculture and Forestry launched a five year research program on adaptation (Climate Change Adaptation Research Programme). The aim of the program is to provide practice-oriented advice on concrete adaptation measures as well as ways to improve the cooperation between relevant actors.

Communication and Education
The Finnish adaptation strategy emphasizes the importance of communication as a key component of Finland’s adaptive capacity. For example, the publication of the strategy was accompanied by a public seminar. Key target groups are local governments and companies.

Research projects on climate change impacts and adaptation are also accompanied by workshops for each of the relevant stakeholders and for journalists.

The winter storm of 2005 raised public awareness for the impacts of climate change in Finland significantly. The storm led to a broad discussion in the Finnish media and the public about the consequences of global warming.14
French climate studies reveal that since 1950, the temperature rise in France has been even greater than the rise of average global temperatures. ONERC estimates that a rise of the average global temperature by 2°C would result in an increase of 3°C in France. Furthermore, extreme weather events, such as storms and heat waves, may increase in frequency, often causing damage to people and infrastructure. The northern regions of France will likely be affected by storms and floods, while the south will suffer from droughts and water scarcity. Climate change will likely have greater impacts on the water balance in the French Pyrenees that in the Alps, and these impacts will affect water supply and winter tourism.

While rising temperatures could potentially raise productivity in some forms of agriculture by between 10 and 30 percent (especially for wheat and corn), water shortages could cause serious problems in southern regions of the country. Furthermore, more frequent storms and hailstorms present greater challenges for farmers. The harvest season for wine has already changed in France, advancing by three weeks during the past fifty years. Increasing pest attacks and crop failures caused by extreme heat represent additional problems. Forestry will also be affected by water scarcity. Other risks of water shortages include the increase of storms and forest fires.

Furthermore, lower rainfall during the summer and increased evaporation can lead to severe water shortages. At the same time, heavy rainfall events will affect water management due to earlier snow melt and a shift in water flow from spring to winter. Another problem posed by climate change is the decrease in water quality from sea level rise (salt water intrusion) and increased water temperatures.

The energy sector also faces significant climate adaptation challenges. The supply of cooling water could become scarce, especially during hot and dry summers. Cooling water shortages can cause power plants to shut down or work below capacity. Additionally, low water levels can hamper the power production at hydroelectric plants. At the same time rising temperatures raise the energy demand in summer as companies and households use more cooling systems. Furthermore, the increased frequency of storms can damage the energy infrastructure such as power lines, substations and transformers.

While there could be an extension of the tourist season in the summer, winter tourism will probably face losses. This is especially relevant for the regions of Savoie, Hautes Alpes and Alpes de Haute Provence, where the number of ski areas could decrease by 20 percent in the case of a temperature rise of 2°C.

Climate change also poses risks to native flora and fauna. Experts expect that 19 percents of all vertebrates might disappear in continental France.
The challenges for the French health and welfare system became apparent during the catastrophic heat wave of 2003, which caused a staggering 14,800 fatalities. Elderly, isolated and infirm persons in urban areas were most affected due to the heat island affect in cities, which did not cool down during the night. Studies indicate that such heat waves could become common place by 2050 and beyond.

Strategy and Actors
The catastrophic consequences of the heat wave of 2003 have increased the pressure on the French government to prepare the country for the impacts of climate change and to develop an adaptation strategy. In November 2006, the government presented the Stratégie Nationale d’Adaptation au Changement Climatique (SNACC). Based on the precautionary principle, the goal of SNACC is to incorporate the consequences of climate change into the strategic planning process. A national adaptation plan with specific adaptation measures is to be developed by 2010/2011. The adaptation strategy identifies four key areas of action:

1. Security and public health
2. Preventing social and economic injustice
3. Cost minimization
4. Protection of biodiversity

The emphasis on justice illustrates that the French strategy also incorporates social and equality aspects. The strategy was developed using an interdisciplinary approach. Experts from ministries, research centers, civic associations and companies were all involved in the process.

The coordination of climate protection and adaptation is directed separately within the Ministry for the Environment and Sustainability (MEDD, Ministère de l’Ecologie et du Développement Durable). ONERC is responsible for adaptation and is tasked to develop a strategic framework as well as recommendations for potential adaptation measures. The institution was established by the French parliament in 2001. It is led by a group of 26 political decision-makers, scientists and representatives of local authorities.

Other important actors are the French Environmental and Energy Agency ADEME (Agence de l’Environnement et de la Maitrise de l’Energie) as well as the ministries for tourism, agriculture and health. The Ministry of Agriculture developed a sector-specific adaptation strategy. The Ministry of Health has developed a national strategy on heat waves (Le Plan Nationale Canicule, or PNC), which was completed in 2008.

Regional and local level
Local French regions and municipalities have also started to consider adaptation options and risk management. Examples include the regions of Aquitaine, Loire, and Rhone-Alpes, as well as the cities of Paris, Lyon and Nantes. Depending on the sectors affected, the cities and regions focus on various impacts such as droughts, water scarcity, insulation of buildings, and reforestation.

Information, Communication and Education
ONERC is in charge of collecting relevant information on the impacts of climate change in France and communicating them to relevant stakeholders and the public. In 2006, the report Climate Change : Consequences for France (Réchauffement climatique: Sources conséquences pour la France) provided the foundation for the development of a national adaptation strategy. ONERC uses conferences, publications, and traveling exhibitions to foster the exchange of information and to raise public awareness. It also advises municipalities regarding the adaptation of urban planning, for example in Le Ferré and Romagné.

Information brochures like the report Municipalities and Climate Change: Are You Ready? (Collectivités locales & changements climatiques: Etes-vous prêt?), published in 2004, informs citizens and communities about the expected consequences of climate change as well as possible adaptation measures (such as insulation and other efficiency measures). However, there are no national adaptation campaigns like those in place in the Netherlands or Great Britain.

Important research and information institutions include the French weather service, Météo-France, as well as the Institute for Sustainable Development and International Relations (IDDRI - Institut du Développement Durable et des Relations Internationales), the French Institute for Biodiversity (IFB - Institut français de la biodiversité) and the French Institute for the Environment (Ifen - Institut français de l’environnement). In 2008, Ifen organized a conference on the adaptation strategies for agriculture and ecosystems. Also in 2008, the research center Climate Mission (Mission Climat), of the French state bank Caisse des Dépôts, launched an international research program on adaptation and the impacts on infrastructure.
Floating Houses and Mosquito Nets: Country Profile

In Germany, temperatures are expected to continue to rise, but regional differences may vary by between 1.5 and 3.5°C (for the period from 2071 to 2100 as compared to the period from 1961 to 1990). There are expected to be fewer days of frost and more days with extreme heat. The frequency and intensity of heat waves are expected to rise, causing public health problems, especially in urban areas.

By the end of the decade, it is expected that rainfall during the summer will decrease on average by 30 percent. However, these changes will differ from region to region. These increases in temperature are expected to lead to increased evaporation. The south, southwest and northeast of Germany have the potential to be most affected by water scarcity. Furthermore, the frequency of extreme weather events is also expected to rise in Germany, posing serious risks to people and the economy.26

The impacts of climate change differ between regions. According to the Federal Environmental Agency (UBA), the southwest of Germany (Upper Rhine Valley), the central parts of Eastern Germany, and the Alps are particularly vulnerable to the impacts of climate change.27 A big challenge for the Upper Rhine Valley will be heat waves, which could significantly burden the public health system. In the lowlands of northeastern Germany amounts of rainfall are expected to decrease, while in the Alps, glaciers will continue to melt and the snow cover is expected to decline.

Along the coast, sea level is predicted to rise by 30 cm. Large variability in the range of predictions means that a much greater sea level rise is also possible. In some coastal areas, an absolute rise of sea level could be further aggravated by an extension of the tides. The courses of the rivers are also increasingly threatened by flooding, especially in the lower reaches of the country.

These changes imply risks both for the health of the population and the economy. During the heat wave of 2003, there were 7,000 additional fatalities in Germany as compared to average summers. The Elbe flood of 2002 cost over 9.4 billion Euros. Other extreme weather events, like storms, have also caused significant damage. In 1999, hurricanes Lothar and Martin caused damages worth 14 billion euros.28

In Germany, climate changes posses risks to nearly every economic sector, including water, agriculture and forestry, public health, energy, transport and infrastructure, tourism (in the Alps and the low mountain ranges), biodiversity and environmental protection, and the insurance industry.

Strategy and Actors

In 2005, the German government decided to develop a com-
Emerging Climate Change Adaptation Strategies Around the World

Prehensive adaptation concept within the framework of its existing climate protection program. In December 2008, the German government passed a national adaptation strategy after an intensive consultation process with numerous scientists, states and other stakeholders. The strategy will be implemented in cooperation with the states, municipalities and other non-profits as well as the private sector. The Federal Ministry for the Environment leads the adaptation efforts, while the Federal Environment Agency supports this process with its expertise and assumes many operational responsibilities.

The goal of the adaptation strategy is to create a framework for the adaptation to global warming and to initiate a process for mid-term impacts. Concrete goals of the strategy are:
- Identifying and communicating threats and risk
- Raising awareness and mobilizing actors
- Providing affected actors with required information for taking decision
- Identifying options, coordinating and defining responsibilities, formulating and implementing measures

The strategy deals with economic sectors like agriculture, forestry, fishery, biodiversity, building, public health, transportation and infrastructure, water and coastal protection, soil, tourism, trade and industry, energy and the financial sector. Cross-cutting issues are land use planning, regional planning and disaster management.

Important next steps will be the improvement of the knowledge base, the start of a broad dialogue and communication process, and the development of a specific Adaptation Action Plan. The plan is to be developed by March 2011. It will identify the most urgent measures, and will also identify funding and performance measurement. Other ministries participate in the drafting of the action plan through an inter-ministerial working group. German states are also involved in the process. The development of the plan will be accompanied by a participatory process.

Work of the Federal Ministries

On the national level, various ministries already deal with climate change adaptation strategies. For instance, in 2007, the Ministry of Transport, Building and Urban Affairs started an initiative on climate change impacts. The goal of the initiative was to assess the possible impacts of climate change on shipping and water ways in Germany. The Ministry of Food, Agriculture and Consumer Protection deals with the possible impacts of climate change on breeding, plant cultivation, animal husbandry, agriculture, and forestry. The Ministry for Economic Cooperation and Development initiated a Climate Check system, which aims to ensure that international development projects improve the adaptability of developing countries.

The Ministry of Education and Research supports different research projects on climate change adaptation. For example, the klimazwei (Climate Two) program aims to develop practice-oriented action plans for different sectors that are affected, including agriculture and forestry, water, tourism, as well as building and urban planning. Additionally, early warning systems and regional networks will be created. The KLIMZUG initiative is intended to support regional adaptation strategies in the regional planning processes as well as to develop and use new technologies for the adaptation to climate change. Finally, the Glowa project (Globaler Wandel des Wasserkreislaufes) develops decision-making support for sustainable water management in the context of climate change.

The States

The German states have also begun to prepare their own climate change adaptation plans. There are numerous studies and analyses regarding the specific impacts in different states, as well as draft adaptation plans for various economic sectors that are affected. In Bavaria, the study Climate Change in Bavaria, which is part of the Bavaria Climate Program 2020, estimates the impacts in the state and formulates recommendations for different policy areas. Furthermore, a new research network has been established (BayFORKAST), which analyses the effects of global warming on ecosystems and proposes adaptation measures. Regional focus areas include the Alps, river valleys and the low mountain range of northeast Bavaria.

In April 2009, the state government of North Rhine-Westphalia presented its own adaptation strategy. Their strategy focuses on flood protection, biodiversity, agriculture and forestry. An important issue in this densely populated state is the impact of rising temperatures and the heat island effect, which particularly affect cities. The Ministry for the Environment therefore plans to develop a handbook on the city climate with concrete adaptation measures, to be evaluated in the model cities of Bottrop and Dortmund. Furthermore, the state government has initiated a competition for municipi-
Floating Houses and Mosquito Nets:

In 2007, the state government of Hesse passed the Action Plan Climate Protection, which includes adaptation measures. In 2008, Saxony developed an action plan on climate change and energy. The Saxony plan also includes adaptation measures for each of the relevant sectors. In Saxony-Anhalt, an interdisciplinary Climate Impacts Working Group has been established to address needed adaptation measures. In Brandenburg, the impacts on agriculture have a high priority due to the rising frequency of extreme weather events.

The coastal states are cooperating within the framework of an Integrated Coastal Zone Management plan in order to adapt to climate change. The participating states are Schleswig-Holstein, Mecklenburg-Western Pomerania and Lower Saxony. Bavaria, Baden-Württemberg and Rhineland-Palatinate have initiated a program on water management (KLIWA) as well.

There is still a great need for additional research regarding the regional impacts of global warming. Regional climate models have been developed by different German research groups (REMO, WETTREG, CLM and STAR 2.0). These models offer climate projections for different regions until the year 2100. These models are integrated with land use models (especially for agriculture) in different state-wide projects.

Communication and Education

During the development of the adaptation strategy, numerous conferences and workshops were held in order to link academia and policy-makers. The plan is to extend this dialog through electronic consultations, sector-specific and cross-cutting dialogues and the initiation of strategic alliances. Besides the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), other participating ministries are also organizing expert talks on different aspects of the climate change adaptation strategy.

In the future, the Federal Environment Ministry (UBA) will become more engaged in the communication of climate change adaptation strategies through public-relations activities, workshops, and dialog projects. The goal is to inform the public about risks and opportunities of global warming.

Information

The Federal Environment Agency (UBA) established the Competence Center for Climate Impacts and Adaptation (KomPass) in 2006 in order to accompany the development and implementation of the national adaptation strategy. KomPass advises the Federal Ministry for the Environment regarding the development of the German adaptation strategy, and helps connect relevant actors. KomPass also serves as an office for the implementation of the adaptation strategy. KomPass plays a similar role to the UK Climate Impacts Programme (UKCIP): to exchange information and advise decision-makers. Furthermore, a Climate Service Center (CSC) was established in 2009 in order to close the gap between basic research and practice-oriented information. The goal is to gather information and present it in a user-friendly way, so that climate data is better integrated into the planning process of policy-makers and business leaders.
Emerging Climate Change Adaptation Strategies Around the World

Great Britain: Institutionalization and “Mainstreaming”

Summary
Great Britain is at the vanguard of climate change adaptation. The country follows a coordinated approach that covers almost all policy areas and involves all key actors, ranging from the Ministry of Environment to the Ministry of Defense. The strategy focuses on integrating adaptation policy into the general political process. For instance, adaptation figures into the government investment process and in the evaluation of municipalities. An important success factor for the British adaptation strategy was the early establishment of an information and coordination center that brings together academia and policy-makers. As a result, municipalities are provided with analysis and assessment tools that help them estimate the risk of climate change and plan the appropriate adaptation measures. Great Britain is more active than many other countries in communicating the need to adapt to climate change. The consequences of climate change in the Great Britain include the risk of flooding, as well as erosion along the coastline and in river basins.

Country Profile
The rising frequency and intensity of extreme weather events have demonstrated how Great Britain is affected by climate change. Examples include the heat wave of 2003, the drought period between 2004 and 2006, and the floods in the summer 2007. According to current projections, the average annual temperature in Great Britain might rise by as much as 5°C by 2080. This would result in more heat waves during the summer season, greater amounts of precipitation during the winter, and increased erosion. By 2080, the risk of floods could rise fivefold. Furthermore, Great Britain could simultaneously be affected by water scarcity, even though many households in Southern England dispose of less water per capita than the inhabitants of most Mediterranean countries.

The increasing risk of flooding represents a particular challenge for the eastern and southern regions. Rising sea levels threaten coastal areas in Yorkshire and Humber as well as the surrounding river deltas. The cities of York and Sheffield were hit particularly hard by the floods of 2007. In addition, Northern Ireland and southwest England will see an increased risk of flooding that threatens infrastructure and the economy in these coastal areas.

In addition to the risk of flooding, coastal erosion threatens local landscapes and communities, including the famous chalk cliffs of Dover. Coastal erosion has been a problem along the British coastline for years, but climate change will aggravate the problem significantly. Dealing with conflicting interests in this regard is especially tricky, as many coastal regions threatened by erosion are at the same time attempting to develop and revitalize their communities by building new coastal housing areas.

Seasonal water shortages present a growing threat for regions of Wales, southern England and the Midlands. Wales alone is expected to see half of its water supply centers experience severe shortages within the next 25 years. These water shortages are slated to occur while rising temperatures create even more demand for water for irrigation and air conditioning. Energy suppliers are also affected by water shortages given their water demand used for cooling power generation systems. Furthermore, the concentration of pollutants in rivers and lakes can increase due to decreasing rainfalls.

Rising temperatures can cause a shift of vegetation zones. This threatens domestic biodiversity, including areas in Scotland, the West and East of England. On the other hand, there could be positive effects for agriculture, since milder winters can allow new crops to be cultivated. However, rising temperatures can also raise the risk of insect and other pest attacks on new and existing agricultural lands.
The rising frequency of **extreme weather events** also increases the risk that rivers overflow. The more frequent change between periods of drought and periods of rainfalls can cause or aggravate land subsidence, which damages buildings and infrastructure.

These examples illustrate how climate change can present new opportunities for the **British economy**, but also substantial risks. While the adaptation to extreme weather events and the protection of ecosystems are associated with high costs, tourism could benefit from climate change. Warmer winters and long dry summers could attract more tourists. However, the British economy and especially the city of London are likely to see negative impacts on the finance and insurance industry as a result of climate change.

**Strategy and Actors**

Great Britain is in the vanguard of climate policy due to its development of a comprehensive approach that involves numerous ministries and actors on the national, regional and local level.

Great Britain started to deal with the consequences of climate change earlier than other countries. In 2000 the necessity to adapt to climate change was recognized and formally included within the UK Climate Change Programme. In 2005, the Department for Environment, Food and Rural Affairs (DEFRA) created the climate change Adaptation Policy Framework (APF). The APF brought together each of the relevant stakeholders and developed strategic guidelines for Great Britain’s adaptation to climate change. Top priorities of the APF include: flood protection, water management, protection of buildings and infrastructure, biodiversity, agriculture and forestry, and the use of coordinated planning approaches.

Building on these results, the Department for the Environment coordinates the education and implementation measures within the framework of Adapting to Climate Change (ACC). The first phase runs from 2008 until 2011. In 2012, the second phase begins, in which the provisions of the recently passed Climate Change Bill will be implemented (see section Climate Change Bill). All relevant government institutions are involved, including the Cabinet Office, the Department for Children, Schools and Families, and the Ministry of Defense. Adaptation is regarded as a cross-cutting issue that has to be integrated in the overall political planning process.

There are five central projects:

- **Political planning**: The rules for assessing the impacts of laws and regulations are reviewed in order to make sure that the consequences of climate change are sufficiently incorporated in the policy planning process. Furthermore, adaptation will be integrated into existing political strategies. For example, linking adaptation with the existing biodiversity strategy is of great importance.

- **Expenditures and investments**: Climate change is also incorporated in cost-effectiveness assessments of expenditures and investments. A working group is currently investigating if the guidelines on adaptation to climate change should be incorporated in the Green Book, which is a central reference for the planning process of expenditures.

- **Procurement and properties**: The consequences of climate change are also to be considered in the procurement process as well as with regard to the use of public properties.

- **Performance measurement**: By the end of 2009, a set of indicators will be developed in order to measure the progress of the adaptation process. The factors that will be evaluated are: the adaptation capacity of the government, the economy, the public, as well as public awareness and policy results.

- **Link to the issue of sustainability**: In Great Britain, adaptation is regarded within the context of previous work done on sustainable development. All British ministries and subordinated agencies are required to develop a Sustainable Development Action Plan, which has to be regularly updated. They also have to report to the Sustainable Development Commission about the progress they have made. It is envisioned that the adaptation to climate change policies and programs will be integrated into this process.

In the end of November 2008, a new **Climate Change Bill** was passed that not only includes new provisions for climate protection, but also creates a legal foundation for the adaptation to climate change. The bill stipulates that every five years the British government has to conduct a country-wide risk assessment. Furthermore, the government is required to develop a national adaptation program for the most urgent adaptation measures; this program must also be updated every five years. Additionally, the bill allows the government to collect reports from public entities and water and energy utilities, in which these entities must explain how they in-
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Corporate climate risks into their work and how they have taken action. The government will publish a strategy that will identify other organizations and agencies that will be affected. The Climate Change Bill also introduces an independent Climate Change Committee (CCC). The aim of this committee is to advise and manage government climate policies. A specific working group within the CCC will provide advice for the implementation of the national adaptation program.

Each of the relevant ministries also started to evaluate the consequences of climate change for their respective portfolios, and some have started to implement specific adaptation measures:

- **Under the title Making Space for Water** the Department for Environment, Food and Rural Affairs (DEFRA) is working on a strategy for flood protection and coastal erosion.
- **In cooperation with other ministries the Department for Business, Enterprise and Regulatory Reform (BERR) has developed a joint strategy for government and the private sector regarding sustainable building that takes the impacts of climate change into account.**
- **Together with other ministries, the Treasury is working on making adaptation investments as cost-effective as possible. Another priority is cooperation with insurance companies regarding damages caused by extreme weather events.**
- **At the end of 2008, the Ministry of Defense published an updated climate change strategy that describes the consequences of global warming for British defense policy and outlines possible adaptation measures. The aim of the strategy is to adapt defense planning, capacities, equipment and instruments to the expected climate impacts.**
- **In cooperation with representatives of the railway industry, the Department for Transport has established a forum in order to identify the challenges climate change presents for the railway network.**
- **Given the rising frequency of very hot summers, the Department of Health has developed a heat wave plan in order to reduce the number heat wave related victims.**

On the **regional level**, the governments of Scotland, Wales and Northern Ireland are each responsible for crafting their own adaptation policies. In order to ensure a coherent national adaptation effort, the working group Adapting to Climate Change UK has been established. Adaptation activities are coordinated in this forum, with particular attention paid to the border regions.

In 2008, the British government introduced a performance indicator for the **local level** in order to evaluate adaptation activities of cities and municipalities. There are four performance levels covering issues from the identification of priorities to developing and updating adaptation action plans. The performance assessments are intended to ensure that municipalities make sufficient provisions for the impacts of climate change and chart progress into the future.

In order to **support cities and municipalities** many institutions offer climate adaptation information materials, guidelines and tools. Two notable examples are the Nottingham Declaration Partnership and the Town and Country Planning Association. The Nottingham Declaration Partnership is a consortium of cities and municipalities engaged in the adaptation to climate change policies. More than 300 local governments have signed on to the Partnership committing to actively deal with the causes and consequences of climate change. In 2006, the Nottingham Declaration Action Pack (NDAP) online tool was developed in order to support the adaptation efforts of cities and municipalities. The online tool is intended to help local authorities with the development...
and implementation of climate protection and adaptation plans.46 In cooperation with the Commission for Architecture and the Built Environment, the Town and Country Planning Association (TCPA) published a handbook on adaptation policy in order to assist local decision-makers (Climate Change Adaptation by Design), especially with regard to the building and construction sector. The goal of the handbook is to emphasize the importance of adaptation measures and to show how such measures can be integrated into land use planning.47

Information
A crucial factor in the success of the British program is the UK Climate Impacts Programme (UKCIP), at the University of Oxford, which was set up in 1997. UKCIP works at the interface of academia and policy-making offering a range of information and advice. It also supports stakeholders in the development process of their adaptation strategies. UKCIP presents complex scientific information in a way comprehensible for decision-makers. It also provides practice-oriented instruments, such as the Adaptation Wizard for the initial analysis of needed adaptation measures, a database with adaptation case studies in Great Britain, and a tool that companies can use to assess the impacts of climate change in a specific sector or business segment. UKCIP has become a role model for other European countries.48

UKCIP also coordinates the research on climate change, and is tasked with the publication of climate scenarios by the British government. In 2009, UKCIP published updated climate projections, including detailed projections at the local level.49 An additional information tool is an interactive user interface that provides decision-makers and interested citizens with forecasts for each of their specific regions.

Communication and Education
The publication of the Stern Report in 2006 raised public awareness of climate change impacts in Great Britain and made a significant contribution to the British and the international debate on climate change. The report predicted that global warming will cause high global costs and calls for greater climate protection efforts, including adaptation measures.50

The UKCIP is responsible for publishing a broad range of papers and communications including brochures and literature for the general public as well as policy makers. For example, specific information brochures like Your Home in a Changing Climate or Climate Change and Gardening create a link between global warming the daily life of British citizens. Additionally, the website your climate your life offers relevant information for citizens on the expected impacts of climate change in Great Britain. The website of the Department for the Environment (DEFRA)51 also presents comprehensive information on the impacts of climate change in different regions of Great Britain as well as on the adaptation programs of the government.

Furthermore, the negative impacts of climate change in Great Britain are openly communicated by the government and policy makers. For instance, since 2000, the Environment Agency (EA) has published maps illustrating the flood and other climate change risks in different areas. These maps show the possible impacts of a massive flood and the effects of flood protection facilities. The aim of the project, which cost 30 million pounds, is to inform the public and local decision-makers about the probability of floods and possible adaptation options. The publication of the risk maps has direct impacts on the real estate prices and on the insurance sector, and builds public awareness of climate change problems and adaptation strategies.
EMERGING CLIMATE CHANGE ADAPTATION STRATEGIES AROUND THE WORLD

Netherlands: Coast Protection, Water Management and Land Use Planning

Summary

A huge part of the Netherlands is situated below sea level. In order to prevent catastrophes like the Storm Tide of 1953, adaptation to climate change is regarded as a matter of national security. Rising sea levels will result in an increased likelihood of flooding. The issue has been on the political agenda for many years, especially in the context of water management, coastal protection, and land use planning. In light of the fact that a rise in sea level is unavoidable, the approach to flood prevention has evolved from fighting against the rising tide to living with and adapting to it.

In 2007, the Netherlands enacted its national program for adaptation. In addition, the Delta Commission was established to develop a flood prevention strategy. The commission published its recommendations at the end of 2008. A law that deals with flood prevention is currently pending.

Country Profile

In geographic terms the Netherlands can be described as an urbanized river delta, half of which is located below sea level. Consequently, compared to other European countries the Netherlands is especially threatened by rising sea levels. In just the last hundred years, sea level has risen by 20 cm at the Dutch coast line. According to calculations by the Royal Netherlands Meteorological Institute (KNMI) sea level could rise by another 35 cm by 2050. For the year 2100 scientists expect a sea level rise of 85 cm. The fact that numerous European rivers like the Rhine and the Maas flow into the North Sea at the Dutch coast further aggravates potential flooding problems. Extreme rainfalls as well as glacial melt due to higher temperatures can cause these rivers to overflow.

The advancing sea water does not only cause a higher risk of floods and rising sea levels. In total, about two-thirds of the Netherlands’ economic performance is generated in parts of the country that are located at very low elevation levels, in some cases several meters below sea level.

Rising temperatures and water scarcity can cause problems in summer. Extreme heat causes urban heat islands, and presents a serious threat to public health, especially for elderly and sick people.

On the other hand, Dutch agriculture could benefit from changing climate conditions. Higher average temperatures can allow for longer cultivation periods and higher profits. Warmer winters could reduce energy costs for the country’s numerous greenhouses.

Climate impacts are ambiguous with regard to the energy sector in the Netherlands. On the one hand, the demand for gas and heating oil could fall due to warmer winters. On the other hand, the increasing use of air-conditioning and other cooling devices could lead to greater energy demand during the summer months. In addition, climate change could have negative consequences for Dutch power plants. Sevel power plants at the Amsterdam-Rhine-Canal and at the North Sea Canal already cannot operate at capacity during very hot and dry periods, because of the lack of cooling water. This problem would become worse as average temperatures rise.
Climate challenges have brought the Netherlands to the technical forefront in the field of water management and flood protection. This expertise is a significant business and economic opportunity for the Netherlands, as other countries are required to deal with rising sea levels and flooding events. For example, modern dike and flood control systems and innovative architectural approaches (e.g., “amphibian” or floating houses) in the Netherlands have attracted interest from other countries.

Strategy and Actors
In the Netherlands adaptation to climate change is regarded as a matter of national security, which gives the issue a high priority in the policy process.

The development of an adaptation strategy started in 2005, lead by the Ministry of Housing, Spatial Planning and the Environment (VROM). In late 2007, a national adaptation strategy was adopted, aimed at making the Netherlands “climate-proof.”

The political debate was initiated by a conference on adaptation to climate change chaired by the prime minister. In 2006, a first version of the strategy was drafted with cooperation among the three levels of government (national, regional, and local). This strategy piece was developed with all relevant stakeholders during more than 50 meetings. By the end of 2007, the updated National Program Climate Adaptation and Spatial Planning was passed by the cabinet (ARK, Adaptatie Ruimte en Klimaat). The focus of the program lies on costal protection, water management, and spatial planning. The program deals with the sectors of water, transport, environment, agriculture, energy, health, industry, and leisure.

The time horizon for the program is the next 100 years. In 2009, a national adaptation agenda is set to be passed, in which specific measures will be defined for the implementation phase (from 2009 to 2015). By 2015, climate change adaptation is supposed to be “mainstreamed” into all relevant policy fields.

The cross-sector ARK program is also intended to improve the coordination and the cooperation between different actors involved in the adaptation to climate change process. For example, “climate-proof” land use plans are developed jointly by each of the relevant national ministries together with the provinces, municipalities, universities and water agencies. The Ministry of Housing, Spatial Planning and the Environment (VROM) coordinates the ARK program. Other ministries and institutions are involved through the steering committee including the:

- Ministry for Transport and Water Management
- Ministry for Agriculture, Nature and Food Quality
- The Ministry of Economic Affairs
- The Ministry for Agriculture and Fishery
- The Association of Netherlands Municipalities
- The Association of Water Boards

An important part of the strategy is the implementation of adaptation strategies at the regional and local level. Provinces and municipalities are currently developing strategies and plans for dealing with climate change.

Route Planner Reports provide the needed information for the program and summarize the current scientific analysis on the impacts of climate change in the Netherlands. The reports evaluate potential adaptation options according to five criteria: importance, urgency, “no-regret” (i.e., a measure makes sense even if climate change will not proceed as predicted), secondary effects, and synergies with climate
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The 46 options with the best evaluations are presented in the report. Of those, 37 percent are related to water management. Only about 15 percent are related to the environment, agriculture, energy and infrastructure. Public health related projects are represented with two percent of the potential measures. This analysis further illustrates the focus of the Dutch adaptation policy on water management.

Rethinking Flood Protection

The Netherlands has a long tradition of water management, as flood protection has been a critical and important activity for the country for many generations. The traumatic North Sea flood of 1953 left an indelible mark on the Netherlands. Nearly 2000 people lost their lives in the catastrophe. In the aftermath the Netherlands developed a unique dike system, and flood protection became a matter of national security.

However, the impacts of climate change are making the Netherlands rethink their traditional water policy yet again. In the future, fighting the water with dikes will not be sufficient: the Dutch will have to learn to “live with the water.” Instead of just focusing on extensions of the dike system, the Netherlands are now embracing an integrated approach to land use planning. It has been accepted that the water cannot be controlled completely and that floods cannot be prevented entirely. Instead the goal has become to ensure good living conditions at different water levels by extending flood plains and using floodable dikes. This kind of rethinking becomes apparent in the action plan Room for the River, which focuses on short term flood protection until 2015.

The paradigm shift is also illustrated by the report Working with Water, published by the Delta Committee in September 2008. The Delta Committee has been established to find solutions that can protect the Netherlands from flooding during the next hundred years. It formulated twelve short- and long-term recommendations that include improving existing dike systems, applying cost-benefit analyses, and extending flood plains. In the introduction to the recommendations, the first Delta Committee established after the flood of 1953, is mentioned, which illustrates the importance of the impacts of climate change for flood protection in the Netherlands. The committee estimates that by 2050 the needed adaptation measures will cost between 1.2 and 1.6 billion euros annually. From 2050, the costs are estimated to be between 0.9 and 1.5 billion euros annually.

Recommendations of the Delta Committee

The Delta Committee has formulated twelve short- and long-term recommendations, which include:

- The standard for flood protection should be increased tenfold for all dikes. In certain areas new dike systems should be developed
- Decisions on development in areas threatened by floods are to be based on cost-benefit analyses. Costs for preventive measures are to be borne by the builder and not by the taxpayer.
- New buildings and infrastructure in areas behind the dikes should not hamper the capacity of rivers and lakes to flow back.
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- New buildings and infrastructure in areas behind the dikes should not hamper the capacity of rivers and lakes to flow back.

The Dutch prime minister announced the presentation of a new Delta Act, in which the recommendations of the Committee will be analyzed.

Information

An important aspect in the Dutch adaptation strategy is the close cooperation between academics and policy-makers. The program Knowledge for Climate program started in 2008 and develops proposals for adaptation measures. The program is based on the cooperation of different institutes and political decision-makers. The program is concentrated on certain “hot spots” like Schiphol Airport, the region of Rotterdam, and The Hague that are particularly affected by climate change.

Additionally, many research programs have been launched within the context of a national strategy for climate change adaptation. These research programs provide the foundation for the strategy and the planning of specific adaptation policy measures. Programs include Living with Water, Space for Climate and Climate for Space, Climate Changes Spatial Planning, and the Route Planner. As mentioned above, the Route Planner Reports summarize the most important findings for the planning of adaptation measures.

Communication and Education

Adaptation strategy development was initiated by a series of high level government conferences. Given the far reaching consequences of climate change on the daily life of the Dutch citizens, comprehensive outreach efforts for the gen-
eral public are planned. In the spring of 2008, the campaign *Living with Water* (*Nederland Leeft met Water*) was launched. Through TV spots, newspaper ads, and placards, the public is informed about the needed changes with regard to the handling of water and the impacts of climate change. In order to inform stakeholders and the general public about climate change mitigation and adaptation, several research institutes have created an internet-platform.

Another information campaign has been started by the De NieuwBouw network. De NieuwBouw wants to encourage young people to develop building concepts that take the risks of climate change into account. Furthermore, the network aims to improve adaptation processes by bringing together clients, builders and consultants in the building sector. Another example is *Climate Magazine* (*Klimaatmagazine*), launched as part of the Space for Climate program. The first issue was printed in 2005, and the focus is on information regarding the consequences of climate change, as well as on tips regarding climate protection and adaptation strategies, such as energy saving tips and effective water management strategies.
SWITZERLAND: ADAPTING DISASTER CONTROL

Summary
As in other countries, climate change will lead to extreme weather phenomena in Switzerland, as well as to fundamental changes in the economic and living conditions in the country. Switzerland can serve as a role model with regard to its response to extreme weather phenomena. This is mainly because climate change aggravates challenges associated with Switzerland’s alpine geography; responding to these challenges has always been on the political agenda. During the last few years, Switzerland has shifted its focus from disaster management to preventative measures. Even so, Switzerland is only now beginning to develop a comprehensive strategy for adaptation to climate change.

Country Profile
One sector that will be significantly affected by climate change in Switzerland is tourism. It is an important part of the Swiss economy; for many regions in the mountains, tourism is the most important source of income. The loss of reliable snow conditions as well as the increasing frequency of extreme weather events such as avalanches, strong rainfalls, and rock falls (due to melting glaciers and permafrost), threaten the financial stability and long-term viability of tourism. It is possible that summer tourism might benefit, as an increased frequency of heat waves in the Mediterranean countries might induce tourists to prefer the lower temperatures in the mountains. 63

Swiss forests will also be affected. Rising temperatures foster the emergence of new insect and pest species and hasten the spread of existing ones. In 2003, a heat wave led to a massive infestation by bark beetles. Between 2000 and 2003, the area burned in forest fires has increased from 36 to 564 hectares. Increased frequency of flooding poses additional risks of storms, avalanches, and mud slides.

Agriculture is also threatened by extreme weather events. However, global warming might also have positive effects. With longer growing seasons, the productivity of farmlands could increase. This could make domestic animal feed cheaper, which is advantageous for stock breeding. The potential profits of many crops could rise if simple adaptation measures are implemented. Nevertheless, in case of a temperature increase of more than 3°C the negative effects will likely outweigh any benefits.

Not only the tourism-related infrastructure, but the overall infrastructure in the Swiss mountains is at risk from climate change. Roads, bridges, cables and buildings have to be adapted to melting permafrost, retreating glaciers and heavy rainfalls. Especially in river valleys, floods can cause significant damage, because many roads and buildings are built close to water sources.

The Swiss water economy is also affected by climate change. About 60 percent of the Swiss energy demand is met by hydropower. This energy source is highly dependent on the amount, timing and geographic distribution of rainfalls, as well as on the flow rate of the rivers. Therefore, the increasing volatility of rainfall and other weather events will require adaptation measures. Some communities, industries, and farms that depend on the melting water from glaciers will face increased water shortages. The volume of Swiss glaciers has already fallen by about 30 percent since 1970. 64 Decreasing rainfalls and increased evaporation reduce the water available for hydropower stations, and thereby can significantly decrease power production. Rising water temperatures further hamper the cooling facilities of power plants. During two months of the summer heat of 2003, Swiss nuclear plants produced 25 percent less energy due to the lack of cooling water availability.

The Swiss banking and insurance sector must also adapt to climate change. Scenarios for future damages have to be developed in order to adapt long-term insurance products that evaluate climate change risks and impacts. Banks have
to adapt their strategy regarding project funding, real estate funding, and their overall investment strategy. In 2007, the Swiss Federal Office of Environment (BAFU) and the Swiss Federal Office of Energy (BFE) commissioned a study to assess the economic costs of climate change in Switzerland. The results suggest that the costs will be relatively moderate until 2050 (0.15 percent of gross domestic product), but they will rise substantially by 2100 to 0.48 percent of gross domestic product.

Public health is threatened by heat waves, avalanches, rock falls, floods, and storms. Other risks include new diseases transmitted by host animals or through the water runoff, and the potential outbreak of tropical diseases like malaria and dengue fever.65

Strategy, Actors and Information
Most adaptation measures in Switzerland are in the area of disaster control. Switzerland has been one of the pioneers of adaptation strategies in the area of disaster control. After a number of natural disasters in the 1980s, Switzerland reassessed the damage potential of such events, and developed comprehensive adaptation strategies. Global warming has always been considered one factor among many others. As early as 1997, the Swiss government launched the National Platform for Natural Disasters (PLANAT). The goal of this commission is to identify gaps in policy and legislation, attempt to avert duplications in the prevention of natural disasters, and to use synergies. Members of PLANAT coordinate programs between the federal government, the cantons (states), the research community, NGOs, and the banking and insurance sector.

In 1999, the Federal Council of Switzerland tasked PLANAT with the development of a comprehensive strategy for disaster control. In 2003, PLANAT presented the strategy entitled Security against Natural Disasters – Vision and Strategy. Based on these recommendations, PLANAT provided an overview of the means and resources used for disaster control.66 The result of this second analysis was the report Strategy for Disaster Control in Switzerland. Based on this report the Federal Council has started the third phase (Strategy for Natural Disasters), which aims to implement PLANAT’s action plan (2005-2008).

Three priorities have been set: risk concept, risk dialogue, and risk control.

- Risk concept
  Integrated risk management detects and assesses risks resulting from natural hazards. Risks are mitigated with an optimal combination of technical, economic, social, and ecologic points of view. Practice-oriented guidelines, as along with training and continuing education, further strengthen integrated risk management.

- Risk dialogue
  A culture of risk awareness is established with a broad dialogue. The responsibilities as well as organizational structures and processes of risk management are also improved.

- Risk controlling
  The risks of natural hazards and the invested funds for prevention measures are systematically monitored and evaluated in order conduct a constant cost-benefit analysis. Risk monitoring is particularly significant given the changing impacts and increasing rate of climate change.

In 2008, PLANAT published an action plan implementation report.67 The implementation is led by the Federal Department of the Environment, Transport, Energy and Communications (DETEC), which coordinates the initiative with other federal agencies. The most important partners are the Federal Department of Defense, Civil Protection and Sport (DDPS), the Federal Department of Home Affairs (FDHA), the Federal Department of Economic Affairs (FDEA), and the Federal Department of Foreign Affairs (FDFA).

A detailed national adaptation strategy, which includes risks and measures besides disaster control, does not yet exist in Switzerland. Switzerland lags behind its European counterparts in this respect. One organization doing work on non-disaster related adaptation measures is the advisory body Organe Consultatif sur les Changements Climatiques (OcCC – the Consultative Body on Climate Change).68 The OcCC has a mandate to develop recommendations regarding climate change for policy-makers and public officials. The focus of the organization lies on climate protection, but its report Climate Change and Switzerland in 2050 deals extensively with both the policy and impacts of global climate change in Switzerland.

New adaptation measures deal with technical requirements for buildings and infrastructure, in urban planning (measures
against the emergence of “heat islands”); agriculture and forestry (adaptation species and breeding); prevention of temperature-dependent germs (establishment of monitoring and warning systems); and regional policy (review of eligibility criteria for support programs according to vulnerability). Such guidelines are developed for architecture, infrastructure and transport systems, and the tourism industry. Federal laws for hydraulic engineering (WBG) and forests (WaG) require the individual cantons (states) to develop risk maps for flooding, avalanches, slides, and rock falls. In turn, these plans must be incorporated in land use plans, zoning plans, and spatial planning. At this point disaster control and adaptation measures have been fully integrated at the local level.

Communication and Education
Switzerland has implemented some preventive measures and information strategies, especially in the area of extreme heat and drought warning systems and fact sheets. For example, in response to the heat wave of 2003, the Federal Office of Public Health (FOPH) provided information and fact sheets and MeteoSchweiz (with the Federal Office of Meteorology and Climatology) did preliminary work for the development of a national heat warning system.

The communication among Alpine countries is institutionalized through a program called PLANALP (Platform of the Alpine Convention for Natural Hazards). PLANALP is the equivalent of PLANAT, at the level of signatory states to the Alpine Convention (Austria, Italy, France, Switzerland, Germany, Slovenia, Liechtenstein, and Monaco). The goal of the network is to coordinate preventive and reactive measures across Swiss Alpine states.
SPAIN: ADAPTATION TO WATER SCARCITY

Summary
In Spain, climate change will most likely lead to water scarcity and rising temperatures. The Ministry of the Environment published a national adaptation plan in 2006, intending to improve the coordination and integration of the climate adaptation measures. In addition to action at the national level, many nongovernmental organizations, municipal governments, and individual companies have implemented adaptation measures. Addressing water scarcity is especially important, and the country has already adopted an action plan to combat desertification.

Country Profile
Important expected affects of climate change in Spain will be water shortage and increasing temperatures. Spain is one of the European countries that will be most affected by an increased frequency of droughts.69 Temperatures in Spain are expected to increase more than in many other European countries.70 Scenarios predict a temperature rise of up to 7°C in the summer and up to 4°C during the winter by the year 2100.71 The strongest temperature increases are expected for the summer month, resulting in an increase frequency of heat waves.

Overall, it is likely that water will become scarcer. Water resources are expected to fall by 22 percent.72 At the same time, water quality will also worsen.

The increase in temperature and decrease in water supply will aggravate desertification, leading to a loss of biodiversity. Today, almost 40 percent of Spain’s land area is threatened by desertification. In the future, up to two-thirds could be at risk.73 These projected climate changes pose serious economic challenges for Spain. Water scarcity, erosion, and desertification hamper the productivity of agriculture. As in other countries, forestry is threatened by forest fires, increased pest attacks, and drought.

Tourism, an important economic sector in Spain, is also seriously affected by climate change. The main risks are extreme heat, water scarcity, and rising sea level, which threaten coastlines, beaches and infrastructure.74

In the energy sector, demand patterns will change. Demand for cooling during the summer months is expected to increase, while demand for heating in winter could decrease. Demand for space cooling could rise by up to 50% by the 2080s.75 Public health will also be affected by an increased spread of certain diseases. Other challenges are the health impacts of heat waves and extreme weather events.

Strategy and Actors
In 2006, the National Adaptation Plan (Plan Nacional de Adaptación al Cambio Climático) was passed. The goal of the plan is to integrate the activities of local and national administrations into one comprehensive cross-sector program. The plan describes the areas and guidelines for impact assessments, risk evaluations, and adaptation measures. It was developed by the national Commission for Climate Change. Relevant industry sectors, as well as the general public, were consulted in the process. The implementation of the plan is coordinated by the Spanish climate change office, Oficina Española de Cambio Climático (OECC), which reports directly to the Minister for the Environment. OECC also designs the national climate policy and supports the implementation. The department Adaptation and Impacts of Climate Change proposes activities for climate monitoring and impact assessment. It also coordinates adaptation activities, and fosters the integration of the latter in sector-specific policies.76

One challenge for implementing adaptation policy in Spain has been the distribution of responsibilities between the national and regional level. The federal Ministry for the Environment has the mandate to define general frameworks and
strategies for adaptation measures. However, the implementation of specific measures lies in the hands of the 17 autonomous regions. Therefore, an important priority is to coordinate research, strategies, priorities, and the implementation of each of the specific adaptation measures.

Specific measures called for by the national adaptation plan are detailed in action plans. The first action plan deals with the following areas:

- Development of regional climate scenarios. A publicly available national data base for climate scenarios collects information and builds the foundation for the development and update of integrated regional scenarios.
- Assessment of the impacts of climate change for water resources. The Center for Hydrographic Studies (CEDEX) develops qualitative and quantitative models and analyzes the impacts of artificial irrigation systems for agriculture.
- Assessment of the impacts of climate change on biodiversity. The goal is to analyze which habitats and species are most vulnerable to climate change.
- Assessment of the impacts of climate change for coastal regions. Experts have identified the most threatened areas and developed a report detailing coastal protection strategies. The results are being incorporated into the Coastal Sustainability Strategy, which was presented to the Ministry for the Environment.

The next action plan will focus on impact assessments for of tourism, health and forests.

Given the serious threat of desertification in Spain, a national program against desertification (Programa de Acción Nacional contra la Desertificación) has been developed. It describes the most vulnerable regions and the main drivers, and identifies specific measures to prevent desertification. Furthermore, the program includes scenarios for different ecosystems and for different forms of agriculture. The action plan includes measures in the following areas:

- **Agriculture**
  - Integration of environmental criteria in agricultural policies, measures to prevent soil degradation, and reforestation of former croplands.
- **Forestry**
  - Reforestation, measures to foster sustainable forestry, and fighting forest fires.
- **Management of water resources**
  - Establishment of a monitoring center for drought, measures for sustainable ground water management, integration of environmental criteria in the national plan for agriculture, artificial irrigation, and the development of action plans for droughts.

Specific water policy measures are already in place. For example, Spain has 700 desalination plants in operation providing drinking water for 8 million people. These capacities are to be significantly extended.
Regional and Local Level

To date, there has not been a comprehensive implementation plan for the National Adaptation Plan at a regional level. The autonomous regions have initiated only a limited number of adaptation measures.

On the local level, adaptation measures are mostly still in the planning stage. However, some concrete approaches have taken shape: The Spanish City Climate Network (Red Española de Ciudades por el Clima) is an association of cities and municipalities dedicated to sustainable development and climate protection. Primarily, the network focuses on the reduction of CO₂ emissions. So far, adaptation to global warming has not been part of the programs; however, the network is currently planning an adaptation program in cooperation with the Climate Change Office (OECC). It also aims to link the activities of cities and municipalities with the National Adaptation Strategy.

Information

In 2003/2004, a research project on the impacts of climate change (ECCE – Efectos del Cambio Climático en España) was developed and published by the OECC and the University of Castilla de la Mancha. The project created a comprehensive updated database on climate change in Spain. The study raised awareness of the fact that Spain needs to implement specific adaptation measures. The study describes the consequences of global warming for ecosystems, water resources, coastal areas, different economic sectors, and public health. The study also includes regional climate scenarios, and the results were incorporated in the National Adaptation Plan.

The most important research institutions in the field of climate change are the National Meteorological Institute (INM – Instituto Nacional de Meteorología), the National Research Council (CSIC – Consejo Superior de Investigaciones Científicas), and several research universities. In addition, the Ministry for Research is launching a national center for climate research.

Communication and Education

In order to raise awareness of global warming and foster understanding among the general public, the Ministry for the Environment has initiated different events and programs. However, there is no systematic communication and education strategy for the National Adaptation Plan. At the moment, outreach activities focus on the issue of energy-saving strategies to reduce CO₂ emissions.
Emerging Climate Change Adaptation Strategies Around the World

Canada is expected to experience changes to its climate that present both risks and economic opportunities. Because of the country’s sheer size and geographic diversity, the impacts vary significantly by region. The arctic regions especially are already affected by climate change, and where local populations depend on natural resources, their livelihoods are already threatened. However, it is also in these same areas where economic opportunities are emerging due to climate change. For instance, with the rising ocean temperatures, new waterways along the Northwest Passage will be accessible, and new natural resources will become available. Adaptation to climate change has been on the agenda of the Canadian government for some time. Nonetheless, most of the specific measures have been developed and implemented by individual provinces or municipalities.

Country Profile

Canada is expected to see some of the greatest rises in average temperatures. According to climate projections, Canadian average annual temperatures are expected to rise twice as much as the global average. Since 1948, Canada has already experienced an increase of 1.3°C. The greatest climatic changes are predicted for the polar and sub-polar regions of the country.

Canada expects both risks and opportunities due to climate change. A recent study on the worldwide risks of climate change identifies Canada as the country that will be least affected by global warming; new opportunities will arise, and the risks are manageable. However, the risks and opportunities are not equally distributed across Canada as a whole. For example, indigenous peoples, which highly depend on natural resources, will be most affected by climate change.

Despite the fact that Canada has very large fresh water reservoirs, some southern regions are already affected by water scarcity. A change in the patterns of melting water from glaciers is leading to flooding during the winter and lower water levels during the summer. There is the risk that the water levels of the Great Lakes and the Saint Lawrence River will fall permanently, which would hamper transport, agriculture, and tourism. Furthermore, Canada has one of the longest coastlines in the world, which make the country especially vulnerable to the rising sea levels.

Canadian agriculture could benefit from moderate climatic changes, as higher temperatures and increased CO₂ concentration lead to longer growing seasons, higher productivity, and increase of arable land. In the case of the Canadian boreal forests, impacts will likely be mixed. Canadian forests are a significant contributor to Canadian GDP and also serve as important habitat for wildlife. On the one hand, increased temperatures and higher CO₂ concentration could foster growth and productivity; however, any of these positive effects could be outweighed by droughts, insect infestation, and the increased frequency and severity of forest fires.

Given their traditional way of life, First Nation populations such as the Inuit of the northern territories, are particularly dependent on natural resources and particularly susceptible to climate change impacts. Today, consequences of climate change such as the reduction of the ice sheet, altered animal migration patterns, and the loss of access to certain fishing grounds seriously affects populations in the province of Nunavut.

Northern regions of Canada are likely to see massive impacts of climate change on infrastructure and transportation. In many regions ice roads are the only viable transport connection other than helicopter. With rising temperatures, the period during which one can use these roads has become shorter and shorter. Furthermore, as the carrying capacity of the ice sheet becomes weaker, it seriously affects volume
and transport capacity. The rise of the melting depth of permafrost grounds is leading to ground instability and causing damage to buildings, pipelines and roads.

Nevertheless, climate change could provide some economic opportunities for Canada. For example, emerging seasonal access to the Northwest Passage, which has always been icy and therefore not passable, has opened up new trade routes. An ice-free Northwest Passage shortens shipping lanes from Asia to Europe by around 7,000 kilometers, compared to the route through the Panama Canal. Canada could also open a new harbor in Bathurst bay. Such transport projects allow improved access to resource extraction sites, making these extraction processes more competitive. However, these opportunities also bring increased environmental threats and habitat loss to vulnerable Arctic regions.

Strategy, Actors and Information

In Canada, all levels of government have been dealing with the consequences of global warming for many years now. Individual provinces and regions are responsible for the implementation of specific adaptation measures. Given the size of the country, the effects of global warming differ significantly between regions.

National Level

The Ministry for Natural Resources (Natural Resources Canada) established a Climate Change Impacts and Adaptation Division that supports research on climate change impacts and possible adaptation strategies, capacity building, the establishment of networks, and the development of adaptation options. In 2008, the Canadian government published a comprehensive report (From Impacts to Adaptation: Canada in a Changing Climate 2007), which shows the risk and opportunities for each region of Canada.

In December 2007, the Canadian government increased available funds for adaptation measures. Over a period of four years, 85.9 million Canadian dollars (CAD) have been provided for a new adaptation plan. The plan stipulates the following investments:

- 15 million CAD for the development of detailed climate scenarios
- 35 million CAD for the design of innovative risk management tools and the development of a regional adaptation programs
- 14 million CAD for Canada’s First Nation populations in order to analyze their most important challenges and risks
- 7 million CAD for adaptation programs in the field of public health, targeted at Canada’s First Nations
- 14.9 CAD for public health related emergency programs (for example, prevention against the spread of infectious diseases)

The Canadian Ministry for the Environment (Environment Canada) cooperates mainly with the Ministry for Natural Resources, the Ministry for Indian and Northern Affairs (Indian and Northern Affairs Canada) and the Ministry of Health (Health Canada) in implementation of adaptation strategies. Other ministries and institutions are involved through individual working groups that deal with specific issues.

There are also sector-specific initiatives developed by specialized institutions. The Ministry for Infrastructure requires adaptation analysis in their application process for some infrastructure funds. For example, institutions that apply for the Canadian Strategic Infrastructure Fund have to show how the proposed project contributes to climate change and adaptation to global warming. The Parks Canada agency develops scenarios for the impacts of climate change on Canadian national parks, and integrates climate indicators into ecological monitoring processes.

Regional Level

The Canadian federal government supports the governments of the provinces and territories in adapting to the impacts of climate change. One example is the program Regional Adaptation Collaboratives (RACs). Natural Resources Canada leads the project, which aims to foster the cooperation between regional governments, NGOs, and experts in order to bundle information on effective adaptation approaches. This cooperation allows for faster adoption of adaptation measures, and supports regional planning and decision-making processes.

Some provincial governments have already developed their own adaptation strategies and measures. In 2008, the government of British Columbia published its own climate action plan. The plan discusses both climate protection and adaptation measures for different areas like fire, flood and drought protection, water management, and pest prevention. British Columbia is also already implementing the Future Forest Ecosystems Initiative, which aims to adapt the management system of forest and mountain regions to this coastal province.
Another initiative is the Ouranos consortium in Québec, founded in 2002. The consortium builds on a partnership between different ministries of the province of Québec, industry representatives, (Hydro-Québec) and academia (Meteorological Service of Canada). The consortium develops regional climate scenarios and organizes stakeholder dialogues to jointly plan and implement adaptation measures.92

Municipal Level
Municipalities have also begun to prepare for the impacts of climate change. Halifax, Hamilton, Ottawa, Toronto and Vancouver have started to incorporate adaptation strategies into municipal planning processes. Another example is the Alliance for Resilient Cities, a network of municipal decision-makers, which supports local administrations in adapting to climate change. The main goal of the alliance is to exchange experiences and to build expertise regarding adaptation measures and policies.93

Information
In 2007, the Canadian government published the study From Impacts to Adaptation, which deals in great detail with regional climate impacts and possible adaptation options. The report was developed in cooperation with academia, the private sector, and Canadian First Nations. The goal is to develop a foundation of knowledge for the development of adaptation policies.

Communication and Education
The communication measures regarding climate change adaptation are primarily implemented by Natural Resources Canada, which has created a web site where scientific results and progress reports are published.94

Between 2001 and 2007, Natural Resources Canada funded the Canadian Climate Impacts and Adaptation Research Network (C-CIARN). Its goal is to generate knowledge and share it among different regions and sectors. One project involves the development of a “toolkit” with educational materials to explain the impacts of climate change on the Great Lakes in a reader-friendly manner.95

Numerous communication initiatives inform professional groups about the significance of climate change and its impacts on different economic sectors. For instance, the Council of Professional Engineers is engaged in fostering continuing education for engineers, to advance the incorporation of adaptation aspects in the planning process for infrastructure and building projects.

A recent survey of the Canadian Standards Association shows that depending on the sector, 70 to 80 percent of interviewed engineers think that climate change will have an impact on their work in the near future. However, the majority believe that they have incorporated the impacts of climate either rarely or not at all.96

There are similar communication approaches being utilized in the health sector. For example, Health Canada publishes a newsletter: Your Health and a Changing Climate. It informs readers about recent developments and research results on the consequences of global warming for public health, to prepare the health sector for these changes.97
**Country Profile**

The United States is a large, geographically diverse nation with a wide variety of climatic regions. It is difficult to generalize about climate change impacts in a country where the impacts are projected to range from reduction of sea ice in Alaska to inundation of low lying areas on the Gulf Coast. According to the Intergovernmental Panel on Climate Change (IPCC) projections, the continental United States will have an increase of 3–7°C in certain regions, with Alaska and the Arctic region projected to warm by 4–11°C over this century.

There has been a surge of research activity during the past few years on the national, regional, and local impacts of climate change. The IPCC and the Union of Concerned Scientists have predicted that with warmer temperatures, current ecological systems will migrate north. Under the IPCC low-emissions scenario, for example, the state of Illinois will have a climate similar to present-day Missouri. Under high-emissions scenarios, Illinois would have a climate similar to Texas. These changes in the regional climate will bring a broad range of impacts. The table below lists the major impacts projected for each region, while the remainder of this section summarizes specific regional impacts as illustrative examples. This section concludes with a brief discussion of potential regional advantages to be gained from climate change.

**Western United States**

The area of the US west of the Rocky Mountains will have unique water resource impacts from climate change. This region depends heavily on snow melt from the mountains to supply water to cities and farms, especially during the dry

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**Description of Regions of the US and their Climate Impacts: Sample of Projected US Regional Climate Impacts**

<table>
<thead>
<tr>
<th>Impacts</th>
<th>Region/States</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal Flooding/Erosion</td>
<td>South, Southeast, Mid-Atlantic, Northwest, Alaska, Northeast</td>
</tr>
<tr>
<td>Hurricanes</td>
<td>Atlantic and Gulf of Mexico coastal areas</td>
</tr>
<tr>
<td>Sea-level Rise</td>
<td>Atlantic and Gulf of Mexico coastal areas, San Francisco Bay/Sacramento Delta region, Puget Sound, Alaska</td>
</tr>
<tr>
<td>Flooding/intense precipitation</td>
<td>All regions, increasing with higher northern latitude</td>
</tr>
<tr>
<td>Decreased precipitation and streamflow</td>
<td>Southwest</td>
</tr>
<tr>
<td>Drought</td>
<td>Southwest, Portions of the Southeast</td>
</tr>
<tr>
<td>Wildfires</td>
<td>Western US, Alaska, Florida</td>
</tr>
<tr>
<td>Intense heat waves</td>
<td>All regions</td>
</tr>
</tbody>
</table>

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**Summary**

The US does not yet have a national adaptation strategy. However, adaptation to climate change has been part of the discussion on the climate protection legislation currently being debated in Congress. Some states are more advanced, with Alaska, California, and Florida being the early pioneers in this field. For instance, California is currently in the process of developing a comprehensive adaptation strategy, and it has already implemented adaptation measures with regard to water management. Alaska also faces the consequences of climate change, and is working on an adaptation strategy.
summers. Less precipitation is projected as temperatures increase, which will stress reservoir and water delivery systems. Many of these reservoirs are in arid, hot climates; with hotter temperatures, evaporation from water stores will increase. The reservoirs created to capture the mountain snow melt in the Southwest, a region with one of the fastest growing populations in the US, are already using up their water allocations. Lake Mead, the largest reservoir in the US, provides water to the Southwest and power to the City of Las Vegas. In recent years, the lake level has dropped to 50% capacity due to drought in the Rocky Mountains. If the drought continues, the lake level could drop below the municipal water intake pipe for Las Vegas in the next few years, and below the intake towers to run the electric turbines within the next ten years. The increased heat and lower precipitation expected for the West will also lead to increased demand on the energy system for cooling, and will double the incidences of wildfires.

Gulf Coast
As tragically demonstrated by Hurricanes Katrina and Rita in 2005, the Gulf Coast is especially vulnerable to a changing climate, due to its relatively flat topography, rapid rates of land subsidence, water engineering systems, and extensive shoreline development. The low-lying topography of the Gulf Coast has led some to predict that large portions of Florida, and large coastal areas all the way to Texas, could be under water by the end of the century in the high emissions scenarios from IPCC. While most of the climate impacts will be felt locally, the region comprising the Mississippi River in Louisiana, the Texas coast, and off-shore in the Gulf of Mexico, are a hub for the production, supply and distribution of oil and natural gas for the majority of the east and central regions of the U.S. The areas of particular concern are the large concentration of oil refineries in Southern Texas and Louisiana, as well as the off-shore oil platforms in the Gulf of Mexico.

East Coast
By the end of the century, it is projected that coastal flooding on the Atlantic coast will affect heavily populated port cities such as Boston, and New York. Waterfront property, transportation and services infrastructure, and New York City’s financial services industry will be at risk from storms and flooding. Severe coastal erosion in popular vacation locales such as Cape Cod, MA, Long Island, NY, and North Carolina will have a severe effect on the economies of these areas and on vacation-property values. The expense of protecting, moving, or rebuilding these coastal resources will be burdensome to regional economies.

Additional economic impacts will result from a warmer ocean and warmer climate. For example, warmer waters along the coast will lead to a further decline in important ocean species such as lobster and cod. The region’s forests are also under stress and will be increasingly susceptible to pests and disease; the woolly adelgid and Dutch elm disease have already affected regional tree cover.

Climate Opportunities
There is less literature on the opportunities presented by climate change in the US than on the potential negative impacts. Several analysts and state governments, however, have identified some positive outcomes of climate change. While crop yield changes in other regions vary more widely depending on the climate scenario and time period, the Midwest, West, and Pacific Northwest are expected to exhibit large gains in yields. There are also projected gains for the forestry industry in some parts of the country, and possible benefits for tourism and recreation industries. As discussed below, the increased melting of the Arctic Sea ice cover will open new marine transportation and trade routes (e.g. between Alaska and Northern Europe), which could decrease the cost of goods and services. Arctic nations have already begun exploring and making claims on the Arctic sea floor in order to gain access to the large off-shore oil and natural gas reserves. Despite these examples, it is projected that the costs of climate change will outweigh the benefits.

Strategy and Actors
As stated in a recent report for the state of California, “Adaptation is being addressed by the international community and largely ignored within the U.S.” Although there are a few positive examples, it is true that federal, state, and local governments in the US are not engaged in climate ad-
Floating Houses and Mosquito Nets:

adaptation to the extent that their counterparts in some other countries are.

There is currently no national adaptation strategy or policy that is supported or endorsed by the federal government. The federal government’s primary approach to adaptation thus far has been research, with limited funding for state and local adaptation initiatives. One of the lead federal climate change research organizations, the Climate Change Science Program (CCSP), recently completed a preliminary adaptation study. The study, however, is limited to ecosystem and natural resource adaptation in federal parks, forest and protected areas, and does not articulate a formal adaptation policy.

At the legislative level, during the 110th Congress the Senate and the House of Representatives considered at least 26 bills related to adaptation, but none of them passed. US energy policy has been changing since the November 2008 election of President Barack Obama. Legislation to introduce a cap-and-trade system is being debated on the national level. The American Clean Energy and Security Act of 2009, ACES, or H.R. 2454, passed the House of Representatives in June 2009. The Clean Energy Jobs and American Power Act, CE-JAPA, or S. 1733, is at the time of writing under consideration in the Senate. Any law passed will likely include important provisions for climate change adaptation. The draft House legislation requires the federal departments and institutions to develop specific climate change adaptation strategies. For instance, the US Department of Health and Human Services (HHS) will be required to investigate how global warming affects public health in the US. Additionally, the adaptation of natural resources is emphasized. The US Agency for International Development (USAID) is tasked to work out a special program in order to support poor countries with their adaptation plans. The states are also required to develop adaptation plans if they apply for federal funds for the implementation of adaptation measures. Furthermore, the law stipulates the creation of a new National Climate Service, which would be responsible for providing states and local governments with information and support for the adaptation to climate change. A special fund to finance adaptation measures is envisioned; and part of the revenue from the cap-and-trade system is intended to fund the adaptation programs.

As will be discussed in greater detail below, most of the adaptation efforts in the US have been at the state and local levels. Given the lack of federal focus on adaptation strategy, the nonprofit sector has increasingly played a coordinating role for state and local policy efforts. Nonprofit, state, and local efforts have received some funds from federal organizations, such as the National Oceanic and Atmospheric Administration (NOAA).

Federal Level

At the national level, the key actors include non-profit organizations such as:

- ICLEI – Local Governments for Sustainability. ICLEI’s Climate Resilient Communities (CRC) is a pilot program, supported by NOAA, to work with US municipalities to pioneer adaptation strategies. The five step CRC plan suggests that cities
  1. study and assess climate resilience,
  2. set goals and prioritize,
  3. develop an action plan,
  4. implement the action plan, and
  5. monitor efforts and re-evaluate the plan.
There are currently four CRC participant cities. ICLEI has also collaborated with King County, Washington, to publish an adaptation strategy guide for local governments.

- Center for Clean Air Policy (CCAP). In 2006, CCAP launched its Urban Leaders Adaptation Initiative, which is working with nine North American cities to develop adaptation policies. The initiative recently received a grant from the Rockefeller Foundation to support city programming.

- The Pew Center on Global Climate Change. The Pew Center maintains an information clearinghouse on adaptation, including proposed federal bills, current state adaptation and climate action plans, and local best practices.

Again, the federal government to date has played a limited role. It has supported some impact research, and has provided limited funding for state and local adaptation initiatives.

The States

Although there have been calls for the federal government to play a greater leadership role, adaptation ultimately requires local implementation. This section focuses on current climate adaptation planning at the state level, and reviews some of the current adaptation efforts being implemented at the local level (other examples can be found in the case-studies section below).

State Level Climate Adaptation Strategy

Despite the lack of a strong federal climate change policy, a growing number of state governments are creating their own climate change strategies. These include regional cap-and-trade agreements (e.g., the Regional Greenhouse Gas Initiative in the Northeast), greenhouse gas inventories, climate action plans, vehicle carbon emissions standards, etc. Several organizations maintain online databases of these initiatives.

To date, state adaptation efforts are in the early stages, and are focused on impact research and planning, rather than proactive implementation. The states that are engaged in adaptation planning include Alaska, California, Florida, Maryland, Oregon, and Washington. Each of these states has recently (within the last two years) convened a multi-stakeholder working group to develop preliminary recommendations for further research or action. In the case of state efforts, it remains too early to identify best practices.

Alaska

With its Arctic location, Alaska is not only warming faster than the rest of the US, but is already experiencing the impacts of climate change. Melting permafrost is causing some buildings to subside, and a broader melt could have severe implications for Alaska’s transportation, oil and gas, and building infrastructure. As a result, Alaska has been actively involved in cataloging both the impacts and opportunities of climate change. Melting coastal ice, for example, could result in a rapid increase of erosion for Bering, Chukchi, and Beaufort sea communities, but melting ice will also open new marine transportation and trade routes (e.g., between Alaska and Northern Europe), which could decrease the cost of goods and services.

In 2006, the Alaska Legislature created a Joint Climate Impact Assessment Commission to study climate change impacts and adaptation strategies. The Commission released its final report in March, 2008. The report presents a comprehensive overview of climate risks and vulnerabilities, and outlines research and assessment priorities—not only for physical adaptation, such as ongoing village relocation studies, but also for administrative adaptation, such as reorientation of the state budget. The legislature’s report complements the work of the executive branch of government, where the Governor’s subcabinet on climate change advises on adaptation strategies and implementation.

One candidate for “best practice” is Alaska’s research effort, which has yielded a comprehensive survey of adaptation needs; and its village initial relocation cost/benefit assessments could represent a template for other states facing relocation in the future. However, adaptation has not yet been fully integrated into state planning, nor implemented as part of a comprehensive program.

California

As with other US states, California’s adaptation efforts are at an early stage. The California Energy Commission (CEC) published a preliminary scoping study on adaptation strategy development in 2006. At the time of writing, the CEC’s Public Interest Energy Research Program has been conducting ongoing research on climate change impacts, risks, and vulnerabilities, with a focus on agriculture and forestry, water resources, and public health.

However, coordinated adaptation planning is just beginning.
In 2008, the California Resources Agency launched the Climate Adaptation Strategy (CAS) process, which took a sectoral approach to adaptation strategy development, focusing on: biodiversity and habitat; infrastructure (roads, levees, buildings, etc.); public health; oceans and coastal resources; water; and working landscapes (forestry and agriculture). The draft CAS report was published in August of 2009, and the public comment period closed in September, 2009.

The Local Level
Urban areas are especially vulnerable to climate impacts, and adapting their established infrastructure will be expensive and challenging. Although the adaptation efforts of municipalities are limited, because many cities do not have jurisdiction over transportation and energy planning, many local governments do have control of water management, city planning, and coastal resources. As a result, some local governments are beginning to use the tools available to them to focus on adaptation and build awareness among local stakeholders. However, as with the federal and state efforts, local adaptation initiatives have generally not progressed beyond the impact assessment and initial planning stages (examples of local government initiatives can be found in the case studies section below).

Information
To date, at the federal level the emphasis has been on research and data collection. One of the most important federal research institutions is the Climate Change Science Program (CCSP), established in 2002. It produces scientific analysis regarding climate-related issues and formulates recommendations. The CCSP has to date published ten status reports on the impacts of climate change, intended as information resources for political decision-makers. Further reports are planned for 2010. A recent study deals with adaptation options in forests, national parks and reservations. Projections on the regional impacts of climate change are produced by the National Oceanic and Atmospheric Administration (NOAA).
Communication and Education
A wide range of education and outreach materials are available to the general public about the hazards of climate change. In the US, the debate on adaptation is fueled by nonprofit initiatives and public interest groups. Important actors include the Heinz Center and the Pew Center on Global Climate Change. The Pew Center, for instance, produces analyses on the current state of adaptation policy in the different states, and on the consequences of climate change for companies.

At the federal level, the US EPA maintains a website that contains information on a broad range of climate change topics, including a page specifically devoted to adaptation.

The nonprofit sector is very active with regard to climate change outreach and education, with groups focusing on national, regional, local, and even neighborhood campaigns. These groups range from policy organizations such as the Pew Center, to bottom-up organizations such as Al Gore’s Climate Project and its allied organizations. However, an exhaustive catalogue of these organizations is beyond the scope of this document.

Al Gore on climate change adaptation measures: from critic to supporter
Until recently, there has been a prominent critic of adaptation to climate change. Former Vice-President, and Nobel peace laureate Al Gore described the adaptation to climate change as a “kind of laziness.” He feared that adaptation to climate change would distract from further efforts of climate protection. However, he has revised his position, and has now become an important advocate of adaptation measures in developing countries.

Quotes
- Al Gore 1992: Adaptation is “a kind of laziness, an arrogant faith in our ability to react in time to save our skins.”
- Al Gore 2007: “We really have to focus on prevention.”
- Al Gore 2008: “I used to think adaptation subtracted from our efforts on prevention. But I’ve changed my mind… Poor countries are vulnerable and need our help.”

Sources
The Economist (2007), Adapt or Die, The Economist Newspaper Limited, September.
James Ford (2008), Emerging Trends in Climate Change Policy: The Role of Adaptation, Department of Geography, McGill University, Canada.
The consequences of climate change in Australia are already apparent. During the last fifty years the average temperature has risen by about 0.9°C. By 2030, the Australian government expects a further rise of 0.4°C to 2°C. By 2070, an increase of 1.0 °C to 6.0 °C is considered possible. At the same time the number of hot days with temperatures of more than 35°C is projected to increase as well.

Furthermore, the frequency of extreme weather events is expected to increase. The intensification of the El Niño Southern Oscillation phenomenon could result in a rising frequency of droughts in combination with individual massive rainfall events. As in other countries, rising sea levels will cause serious problems for the coastal regions of Australia. However, Australia faces a special challenge, in that about 80 percent of the Australian population lives within 50 kilometers or less from the coast line. This implies the need for extensive adaptation measures in infrastructure and the structure and location of cities.

Australia is especially vulnerable to droughts as the country is already battling with water scarcity issues. For most parts of the country, an overall decrease in rainfall is expected; for some regions, the projections are dramatic. In the case of Melbourne, water resources are expected to decrease by 7 to 35 percent by the year 2050. For the Murray-Darling Basin, the greatest river basin in Australia, a decrease of 10 to 25 percent is expected. Only the north is expected to see an increase in the amount of rainfall. Overall, the number of drought months is expected to rise by up to 20 percent by 2030.

The drought of 2002/2003 was the first extreme weather event that Australian scientists directly attributed to anthropogenic climate change. By the end of 2002, almost two in three Australians were affected by a shortage of rainfall. The expected costs to the Australian economy were about 6.6 billion Australian dollars.

Besides the increasing risk of droughts due to falling amounts of rainfall and increasing evaporation, the degradation of water quality represents another challenge. The problem is aggravated by the rising demand for water. In some regions water sources are already depleted.

Water scarcity will also have serious negative effects on Australian agriculture, which contributes 3 percent to the Australian gross domestic product. During the drought of 2002/2003 the value of agricultural production fell by almost a fifth.

Due to the increasing heat and drought, the risk of forest and brush fires rises as well. While single events like the catastrophic fire in early 2009—in which more than 200 people died and more than 7,000 people lost their houses—cannot be directly attributed to climate change, the fires followed a period of extreme weather conditions with very high temperatures, which will become more likely given current climate change scenarios.
The unique biodiversity of Australia is also affected by climate change. 85 percent of the flora and 84 percent of the fauna are endemic to Australia. The Great Barrier Reef exemplifies the serious threats to this unique flora and fauna posed by rising temperatures and other extreme climatic developments. Rising temperatures have lead to intensive coral bleaching, threatening the reef, a landmark of Australia and a UNESCO World Heritage site.

Strategy and Actors
In 2004, the Australian government presented the National Climate Change Adaptation Programme, with the goal of preparing Australian government agencies and the most vulnerable economic sectors for the impacts of climate change. In 2005, the government published the Climate Change Risk and Vulnerability report to define the direction of Australian adaptation efforts. The report showed how both industry and society can benefit from early adaptation measures.

In 2007, the Council of Australian Governments (COAG) passed the National Climate Change Adaptation Framework as a national framework for the adaptation to climate change. The COAG is the most important platform of the federal state. It includes the federal prime minister and the prime ministers of the states. Since 2007, the newly established Department of Climate Change directs the coordination of the national adaptation framework.

The development of the national framework was based on different analyses and studies, which involved numerous stakeholders from academia as well as affected decision-makers. It represents the foundation for all future adaptation measures to be undertaken by the government during the next five to seven years. The framework includes possible adaptation measures, but it does not stipulate binding targets or timetables. The latter are to be defined in an implementation plan. Progress reports regarding the national framework are published every two years. A complete update will be done in four years’ time.

Two priorities for adaptation measures have been emphasized:

1. Improving the knowledge of climate change and building adaptation capacities. An important measure is the establishment of the Australian Centre for Climate Change Adaptation, which is tasked with providing the data for future action (see section on information, below).

2. Reducing the vulnerability of important sectors and regions. Important sectors are water, biodiversity, coasts, agriculture, fisheries, forestry, public health, tourism, land use planning, and infrastructure.

Especially in the case of agriculture and the environment, several measures are already being implemented, and sector-specific plans are being developed:

- The initiative Australia’s Farming Future, developed by the Department of Agriculture, Fisheries and Forestry, provides funds for research and development, for continuing education programs for affected actors, and for the creation of networks among these actors. Additionally, farmers are provided with grants for needed adaptation measures.

- In cooperation with the private sector and state and regional governments, the Department of Agriculture, Fisheries and Forestry is currently working on a Climate Change and Forestry Adaptation Plan.

- Through the initiative Water for the Future, the government invests about 13 billion Australian dollars over a period of ten years for improvements of water management. An important priority has been the Murray-Darling Basin, which is hit especially hard by global warming. In this case, new rules for the amount of water that can be withdrawn have been developed.

- The Reef Rescue program, developed by the Department of the Environment, implements numerous measures for improving the water quality of the Great Barrier Reef. The goal is protect the world famous reef from the potentially devastating impacts of climate change.

The National Drought Policy of the Australian government will also be updated. Studies have been commissioned for different areas, to identify misguided developments and to develop appropriate counter-strategies. Initial results show that efforts to handle periods of drought in the agricultural sector have often failed because they did not involve enough of the affected parties. Other deficits include the lack of coordination among the involved parties on different levels, and the fact that efforts are duplicated in some areas and utterly lacking in others.

The Regional Level
Because of Australia’s federal structure, the states are responsible for many sectors, including those most affected by climate change. Therefore, the states have begun to consider...
needed adaptation measures. For instance, the government of New South Wales integrated a section on adaptation in its climate plan. New South Wales initiated research programs on the regional impacts of climate change, as well as programs for environmental monitoring and capacity building. To protect biodiversity against the impacts of climate change, the Biodiversity and Climate Change Adaptation Framework has been passed.138

The state of Queensland developed the action plan ClimateSmart Adaptation 2007-2012, focused on the sectors of water, agriculture, settlements, nature, emergency planning, public health, tourism, industry, and finance and insurance.139

In 2006, the state of Victoria initiated the Climate Change Adaptation program, which has a budget of 14.8 million Australian dollars for a period of four years. The goal is to generate scientific insights and to develop technical know-how.

The Local Level
The Australian government is also supporting local level implementation of adaptation measures. The report Climate Change Adaptation Actions for Local Government provides approaches for local decision-makers. The goal of the report is to identify appropriate approaches for Australian municipalities. The Local Adaptation Pathways Programme offers funding for local governments that extend or improve their adaptation capacities. The aim is that through risk assessments and the development of action plans, local governments can better prepare for climate change and integrate adaptation in their decision-making processes.140

Information
An important part of the adaptation framework is to improve and coordinate Australian research activities and information campaigns. The Commonwealth Scientific and Industrial Research Organization (CSIRO) is a crucial institution for the study of climate change impact in Australia. It analyzes the impacts of climate change and develops climate projections as well as forecasts. The agency also conducts vulnerability assessments and develops adaptation options. Through the national adaptation framework, the organization has been provided additional funds for a National Research Flagships report on adaptation strategies. These “flagships” are practice-oriented research programs in different fields.141

1. Pathways to adaptation, positioning Australia to deal effectively with climate change
2. Sustainable cities and coasts
3. Managing species and natural ecosystems in a changing climate
4. Adaptive primary industries, enterprises and communities

The Australian government also announced a plan to provide 126 million dollars over a period of five years for a new research and information center devoted to a national climate adaptation plan. One important finding of the adaptation framework was that research on climate impacts and adaptation has been too fragmented in Australia. The new Australian Centre for Climate Change Adaptation has been established to remedy this, by coordinating dialogue and providing government, companies, and municipalities with information about climate risks and adaptation options. The center is tasked with defining strategic research priorities and with connecting existing initiatives across sectors and disciplines. Examples include the development of protective measures and the planning of an early warning system for heat waves.

Communication and Education
The new Australian Centre for Climate Change Adaptation will play an important role in communicating and educating decision-makers and the public about the need for adaptation to climate change.

The development and spread of related expertise is fostered in other ways. The National Climate Change Adaptation Framework mentions the need for continuing education and training for professional groups that are highly relevant to adaptation strategies. For example, the Australian Institute of Landscape Architects has initiated the Climate Change Adaptation Skills for Professionals Programme. This program fosters training for engineers, architects and other professional groups, so that participants learn to integrate the implications of climate change into their work. By 2011, the initiative aims to introduce specific standards for training within different educational fields.142
Emerging Climate Change Adaptation Strategies Around the World

EMERGING MARKETS AND DEVELOPING COUNTRIES

The particular risks for emerging markets and developing countries

Developing countries have been especially hard-hit by the impacts of climate change. Climate impacts will become even more dramatic in the future, especially in the case of the Least Developed Countries (LDCs). Disparity lies in the fact that these are the same countries that have not significantly contributed to climate change. Existing problems like poverty and resource scarcity will be further aggravated by the consequences of global warming. At the same time, these countries have only very limited financial and governmental capacity to deal with the impacts.

Vulnerability

The economies of most developing countries are highly dependent on agriculture, making them particularly vulnerable to global warming and other climate change impacts. Many countries are predicted to suffer from changed patterns of precipitation, droughts and sudden floods. According to the IPCC, the agricultural productivity of some African countries might fall by 50% by 2020, and even by 90% by 2100. This is a frightening scenario, especially for many small farmers.143 Existing problems like water scarcity, desertification, the loss of arable land, floods, deforestation, environmental damages, and the outbreak of epidemics will be aggravated by climate change and increasing temperatures. Furthermore, the ecological balance of many important ecosystems located in the developing world is at risk. Prominent examples include the Amazon rainforest, Himalaya glaciers, and the Sundarban mangroves between India and Bangladesh.

Lack of Adaptation Capacities and Funding

Often developing countries lack the technical and economic resources needed to adapt to the impacts of climate change. For example, funding is often lacking for improvements to water management systems or innovations in agriculture. Weak regional cooperation and the lack of institutional capacity also present problems, especially in the case of transnational water resources. Coordination and cooperation of water resources across borders is a crucial precondition for sustainable water resource management.

The needed adaptation measures will require massive investments. However, there are different opinions about specific program costs due to uncertainty surrounding the local impacts. Furthermore, experts do not agree as to which costs should be regarded as adaptation costs. For example, the United Nations Development Programme (UNDP) expects costs to rise to 86 billion USD by the year 2015.144 Meanwhile, the World Bank estimates annual costs between 75 and 100 billion USD from 2010 to 2050.145 Given their lack of financial resources, developing countries will not be able to bear these costs alone.

The Bali conference of 2007 emphasized that industrialized countries have to act, especially given the fact that they are responsible for the majority of past and current climate emissions, even while the share of emissions from emerging markets rises.

As a result, a central question of the post-Kyoto negotiations for a new climate pact at the Copenhagen Conference in December 2009 will be how to fund adaptation measures. Developing countries are demanding that funds for adaptation measures be provided on top of existing development aid.

Three special funds have been established to support climate change adaptation measures in three different ways: the Special Climate Change Fund (SCCF) for adaptation activities, technology transfer and capacity-building; the Least Developed Countries Fund (LDCF), which supports the group of 49 least developed countries; and the Adaptation Fund (AF), which helps developing countries that have ratified the Kyoto Protocol.

However, the industrialized countries have so far pledged a fraction of the estimated financial requirements. It is unlikely that there will be specific pledges before the conference in Copenhagen in 2009. Observers of climate talks expect that developing and emerging markets will only accept new targets for the reduction of greenhouse gas emissions if the industrialized world agrees to provide substantial financial support as well as to facilitate the transfer of green technologies.
Adaptation Policy in Developing Countries

Thus far, most developing countries have only implemented the most-needed, immediate adaptation measures. In most cases, long-term strategies do not exist, in part due to the lack of reliable data on the specific regional impacts of climate change. This is particularly true for large parts of Africa, where available information is largely insufficient. The level of available data has even deteriorated in recent years, and many developing countries lack reliable climate models and projections. Therefore, adaptation measures are forced to focus on urgent local needs rather than national plans. However, some countries, like South Africa and India, already have advanced information and models on climate change impacts, and have started planning their adaptation measures.

The impacts and challenges that climate change poses to developing countries was first discussed during the seventh conference of the climate convention in 2001 in Marrakesh. The least developed countries, a majority of which are located in Africa, were tasked with developing National Adaptation Programmes of Action (NAPAs), in order to identify and prioritize the most urgent adaptation measures. The United Nations Framework Convention on Climate Change (UNFCCC) developed guidelines for the development of these NAPAs. The main goal is to involve affected stakeholders in the planning process, to collect information on local climatic changes, and to give each stakeholder an opportunity to benefit from other’s experiences. Furthermore, an expert group was established, which guides the process and helps countries implement concrete adaptation measures. Meanwhile, many of the LDCs possess national action plans, although many of them have been passed only recently. At the moment, it is difficult to assess the implementation of the proposed projects. Overall, the NAPAs are only considered a first step, and many additional efforts must follow to prepare developing countries for the consequences of climate change.
Emerging Climate Change Adaptation Strategies Around the World

SOUTH AFRICA: WATER SCARCITY AND UNIQUE BIODIVERSITY AT RISK

Summary
South Africa faces serious challenges associated with climate change. Water scarcity is already very high on the political agenda, and climate change will further aggravate the water situation. Other important challenges include public health effects. Biodiversity loss will be especially economically important, given the country’s unique natural habitats and their relevance to the tourism industry. South Africa is better prepared to deal with the consequences of climate change than many other African countries, because of the availability of more reliable climate data and projections than other African states. Since 2004, South Africa has had a national climate strategy that addresses the need for adaptation. A more detailed adaptation policy is currently under preparation and is expected to be released in 2010.

Country Profile
Since the end of apartheid in 1994, South Africa has been considered a successful democracy with considerable economic and political weight in the region and the rest of the continent. South Africa has the greatest gross domestic product in Africa. The greatest share of the South African economy lies in the extraction of resources. Agriculture and tourism are also important economic providers of jobs. However, the lasting impacts of apartheid present a challenge for economic and social policy, and they can hamper the integrated implementation of nation-wide adaptation strategies. The danger is that only those provinces with considerable economic strength will protect themselves against climate risks, while the poor provinces fall behind.

Climatic conditions in South Africa are extremely heterogeneous. The coastal regions of the southeast and northeast are mainly characterized by a subtropical climate, while the west is dominated by desert conditions (Kalahari, Namib). Average annual temperatures in South Africa range between 25 and 35°C. Half of the South African territory consists of dry and semiarid regions, which makes agriculture very vulnerable to reductions of rainfall.

Sectors that will be affected by climate change include health, agriculture (especially corn), grassland, water, and biodiversity. Diseases like malaria that are transmitted by host animals are expected to spread, and water scarcity will cause more and more health problems. The high incidence of HIV/AIDS also increases the vulnerability of South Africa.

South African agriculture will be particularly affected by the consequences of climate change. 70 percent of South African grain production is corn, and a warmer and dryer climate could reduce corn production by 20 percent. Animal feed, as well as the cultivation of fruits and wine, are significant agricultural crops for the South African economy, and these crops will be significantly affected by climate change. Cattle breeding is also threatened by droughts, the increased risk of major fires, and an increased threat of diseases like foot-and-mouth.

Changes in rainfall and regional water shortages will probably be one of the main problems associated with global warming in South Africa, as it threatens both the livelihood of the people who depend on agriculture as well as the unique biodiversity of the country. South Africa’s rich and unique biodiversity is not only an environmental asset, but also an important economic resource. Both the coastline around the Cape of Good Hope and the dense web of national parks of the mainland have rich flora and fauna. There are 336 tree species, 114 reptile species, 507 bird species and 147 mammal species found in Kruger National Park alone. This rich biodiversity is of great economic significance for South Africa. 60 percent of tourists visit South Africa to view these natural resources. Rising temperatures and droughts especially threaten this ecological resource. The habitats for fauna and flora are projected to decrease by 55 percent during the
next 50 years. An average rise of temperatures between 2.5 and 3°C above 1990s levels would result in the extinction of about 66 percent of animal species in Kruger National Park.

### Strategy and Actors

South Africa is more advanced than other African countries regarding the development of a national adaptation strategy. In 1997, the need for a strategic approach to adaptation was acknowledged during the ratification process of the UNFCCC. The National Committee on Climate Change (NCCC), founded in 1994 as an advisory body, was tasked with coordinating the development of a white paper on climate change for the government. However, consultation with different stakeholders revealed that an integrated national climate strategy had to be developed. Therefore, instead of a white paper, the Climate Change Response Strategy was passed in September 2004. It is the most important strategic document on the impacts of climate change in South Africa, dealing with both climate change mitigation and adaptation. Important topics of the strategy are health, agriculture, biodiversity, water, and grassland. Adaptation measures in the climate change strategy are also regarded as a contribution to the broader goals of poverty reduction and job creation.

The Department of Environmental Affairs and Tourism (DEAT) directs the implementation of the strategy. The Department of Minerals and Energy (DME) plays an important role as well. Six other ministries (foreign affairs, trade and industry, water and forestry, housing, transport, culture and research) are involved through the National Committee on Climate Change, on which local governments, companies, unions and NGOs are also represented. The committee advises the DEAT regarding issues related to global warming.

The Climate Change Response Strategy puts climate change adaptation in the context of South Africa’s overall development efforts. It emphasizes that many adaptation measures, for example in the health sector, are useful independent of the exact consequences of climate change. The overarching goal of adaptation is the reduction of South Africa’s vulnerability to climate change. The strategy defines areas where adaptation is necessary, as well as outlining possible adaptation measures.

For the health sector, the strategy calls for the extension of health protection and health promotion measures. One concern is that climate change will undo progress that has been reached in the health sector, for example in the area of access to drinking water. This would require additional efforts in the health sector. One example is the increased surveillance and monitoring of areas that are prone to diseases like malaria and schistosomiasis (bilharzia). In addition, the response strategy requires an extension of current programs that provide households with preventive tools such as mosquito nets.

For the water sector, the strategy calls for water management as well as contingency planning. The efficient use of water will be a key challenge for the future of South Africa, even though the country already has a sophisticated water management system. An important foundation is the National Water Act, which was adopted in 1998. The act defines water as a public good and establishes rules for water extraction by different user groups. As a result, South Africa has a stronger adaptive capacity in the water sector than other states in Africa, but further measures will be necessary. The strategy outlines goals for the improvement of monitoring systems, strategic resource management, flexibility in water use allocations, demand management, conservation measures, contingency planning for extreme events, and the improvement of infrastructure.

An adaptation plan for the use of grassland includes improvement of the forecasting systems for fires and droughts, as well as preventative measures for disease control. For agriculture, the strategy states that given the increasing water scarcity, irrigation could become too expensive in some
regions, and therefore it will likely be necessary to relocate production areas. Another measure is the planting of drought resistant crops, in order to ensure food security.

Another important topic is the protection of biodiversity. The strategy describes the protection of plant, animal, and marine biodiversity. Adaptation options include the establishment of conservation area networks to buffer the affects of climate change, monitoring systems for plants and animals that are at risk due to climate change, and the use of seed banks for species at risk. It is considered necessary to create a mechanism to assess and prioritize different species, since it will not be possible to save all of them. The South African government has focused investments on monitoring animal and plant populations as well as on the preservation of plant genomes.

Recently, the South African government initiated a process to develop a detailed National Climate Change Response Policy. A first draft was published at a conference in March 2009. Conference participants included representatives of several ministries, companies, unions, NGOs, and other stakeholders. Climate change adaptation will be an important element of the policy. The goal is to develop a policy white paper through a participatory process by 2010. In addition to the University of Cape Town, other important research institutions include the University of Pretoria, the University of Stellenbosch, the South African Botanical Institute (SANBI), the South African Weather Services as well as the Council for Scientific and Industrial Research (CSIR). The CSIR was established by the parliament in order to coordinate efforts between academics, business leaders, and policy-makers.

Communication and Education

The Climate Change Response Strategy emphasizes the importance of communication and education for climate change adaptation, and states that there is still much to do in this area. But compared to many other African countries, South Africa is more active in communicating climate change impacts to its population.

The Ministry of Science and Technology is developing a National Climate Change Vulnerability Atlas. The atlas will describe the regional impacts of climate change in South Africa and can be used as a starting point for planning adaptation in practice. The University of Stellenbosch supports science journalists who report on climate change in South Africa.

“Adaptation Apartheid:”
A South African Perspective

In light of the existing social tensions in South Africa and the historical heritage of apartheid, the issue of adaptation to climate change is also discussed in terms of equity. Nobel Peace Prize Laureate Archbishop Desmond Tutu warns against the threat of a “global adaptation apartheid.” He points to the injustice that the inhabitants of developing countries, such as the slum dwellers of Haiti or the peasants of Malawi, are hit hard by the impacts of climate change even though they did not significantly contribute to global warming. In contrast, industrialized countries, which have been the main emitters of greenhouse gas emissions, have sufficient means to protect their citizens. Therefore, Tutu calls on the global community to integrate adaptation in the international agenda for antipoverty measures.

Source

Country Profile
The Republic of Tanzania, located in East Africa, is characterized by an extraordinary diversity of natural habitats: the country comprises tropical forests, savannahs, swamplands, high plateaus, and Kilimanjaro, the highest mountain peak in Africa. Tanzania has important water reservoirs (Lake Victoria, Lake Tanganyika, and Lake Malawi) and it contains one of the most important nature reserves in the world: Serengeti National Park. Climate change therefore affects Tanzania in multiple ways, yet due to widespread poverty Tanzania has only limited adaptation capacities. About 58 percent of the Tanzanian population lives on less than a dollar a day and is highly dependent on natural resources and subsistence agriculture. Therefore, the livelihood of much of the Tanzanian population is seriously threatened by global warming. The most affected sectors include agriculture, water, public health, biodiversity, and energy.

Agriculture is by far the most important economic sector for Tanzania. It contributes about 40 percent of the gross domestic product, and about 80 percent of the population works in this economic sector. More frequent and stronger droughts are threatening the food security of great parts of the Tanzanian population. In the future, farmers will have to deal with greater climate variability and with changing conditions for cultivation. While rainfall will decrease in some areas, other areas will see an increase. This could lead to crop failure due to droughts or flooding. For instance, the government expects that due to temperature increases and changes in precipitation patterns, corn harvests will fall by 33 percent on average throughout the country. In the central regions, it could fall by up to 84 percent. On the other hand, the harvest of coffee could increase by 16 to 18 percent. Climate change will also reduce the availability of grazing lands for farm animals, so that supply shortfalls become more likely and existing conflicts about grassland are aggravated.

Many rivers, including the Rufiji, Pangani, and the Ruvu, cross Tanzania. They are a highly significant source of water and energy supply. The water level in these rivers is expected to change as a consequence of climate change, but with strong regional differences. While a decrease of water flows is predicted for the Pangani river basin, an increase is likely for the Rufiji. These changes will have great impacts on the population’s access to water, because two-thirds of all households are dependent on natural water sources. Water availability will also affect energy supplies, especially hydroelectric facilities.

One main impact of climate change on public health in Tanzania is the increasing spread of malaria, already one of the most frequent causes of death. The disease recently spread to regions of Kilimanjaro, Arusha, and Tanga, areas where it has not been observed before. If the current trends of rising temperatures and changing patterns of precipitation continue, the occurrence of malaria will continue to spread, particularly affecting children and the poorest segments of the population.
The coastal areas of Tanzania are threatened by a rise in sea level. The coastal city of Dar-es-Salaam—the largest city in Tanzania—and the island of Zanzibar will be particularly affected. Additionally, important habitats, such as Tanzania’s coral reefs and large mangrove swamps are at risk. If the mangroves and reefs were to disappear, the erosion of coastal grounds would increase and the risk of flooding would rise even further.

Tanzania has unique biodiversity with many species being endemic to Tanzania. Currently, 19 percent of the country consists of nature reserves or national parks. The protection of this diversity is of great economic significance, given the importance of tourism for the Tanzanian economy. But increasing temperatures and changing precipitation patterns pose a threat to this biodiversity. Another concern is the melting of glaciers on Mt. Kilimanjaro: during the 20th century, glaciers shrank by 80 percent, and they likely to disappear completely by 2015-2020.

More than 90 percent of the energy use of Tanzania is currently met with biomass production, especially from wood. Another significant source is hydropower. The government estimates that hydropower could potentially cover 90 percent of national energy demand. However, past changes in precipitation patterns and water flows of rivers have already reduced the production of hydropower. These changes will increase in the future, limiting the potential for the expansion of hydropower.

Overall, climate change impacts threaten to aggravate the existing strain on natural resources. Many agricultural problems, such as erosion, soil degradation, deforestation, and falling ground water levels are not caused by climate change. But climate change will further aggravate these problems.

Strategy and Actors
As one of the Least Developed Countries (LCD), Tanzania is obligated by the UNFCCC to develop a National Adaptation Programme of Action (NAPA). In 2007, Tanzania fulfilled this obligation. The NAPA is the main strategic document of the Tanzanian adaptation policy.

The main objectives of the NAPA are:
1. To identify and develop immediate and urgent NAPA activities to adapt to climate change and climate variability
2. To protect life and livelihoods of the people, infrastructure, biodiversity, and environment
3. To mainstream adaptation activities into national and sectoral development policies and strategies, development goals, visions, and objectives
4. Increase public awareness of climate change impacts and adaptation activities among communities, civil society, and government officials
5. To assist communities to improve and sustain human and technological capacity for environmentally friendly exploitation of natural resources
6. To complement national and community development activities which are adversely affected by climate change
7. To create long-term sustainable livelihood and development activities at both the community and national level

The environmental department of the vice-president is responsible for the development of NAPA; however, many other actors are also involved. The research team is interdisciplinary, and the data on vulnerability and adaptation measures was collected collaboratively. Stakeholders from academia, government, the private sector, and the local level were involved in the development of the NAPA. An important goal of involving stakeholders was to foster the collection of information and climate data, because, as with many other developing countries, the current data base on expected climate impacts is very limited. Therefore, planning processes and specific adaptation measures are often based on local knowledge and those climate impacts that can already be observed. The drawback to this approach is that it does not allow for any long-term planning.

Hence, the primary goal of NAPA is to identify the most urgent measures. In total, 72 projects have been analyzed, 14 of which were selected to begin the implementation phase. Most of the projects in Tanzania concern agriculture and water resource management (irrigation, water saving, rainwater collection); however, energy and tourism also play an important role. The implementation of the most urgent projects has just started (see project case studies in the appendix). NAPA adaptation projects are focused at the technical level;
they include, for example, irrigation and water storage infrastructure plans, and electrification measures using micro-hydro power. Further priorities are the sustainable use of scarce natural resources and the development of drought-resistant seeds.

The implementation of the identified projects is not centralized; rather, it is distributed among the responsible ministries. Many adaptation projects are funded by international organizations like the United Nations Development Programme and the International Bank for Reconstruction and Development.

Information
As in other African countries, the lack of resources limits the systematic collection of data and the communication of information on climate change in Tanzania. The research information used for the NAPA is mainly provided through studies by the Tanzania Meteorological Agency (TMA). In other cases, international studies, especially from the IPCC, are used. Other institutions that deal with the consequences of climate change in Tanzania are the University of Dar-es-Salaam, the Tanzania Forest Conservation Group (TFCC), and the Food Security Information Team. Furthermore, different NGOs are working to improve the available data base on climate change in Tanzania. For example, the NGO SouthSouthNorth has completed a study of the impacts of climate change in Tanzania and proposed possible adaptation measures.171

Communication and Education
Communication and education efforts regarding the consequences of climate change in Tanzania have been primarily made during the development of the national adaptation action plan. Information and education are also seen as important components for the implementation of projects.

The most urgent adaptation measures in Tanzania
Among 72 projects that have been analyzed as part of the NAPA process, 14 have been prioritized by the government:
1. Efficient crop production irrigation that boosts yields and conserves water
2. Alternative farming systems and water harvesting
3. Alternative water storage programs and technology for communities
4. Community-based catchments, conservation, and management programs
5. Alternative clean energy sources, such as wind, solar, and bio-diesel, to compensate for lost hydro potential
6. Cogeneration in the industry sector, to compensate for lost hydropower potential
7. Afforestation programs in degraded lands, using more adaptive and fast growing tree species
8. Community forest fire prevention plans and program
9. Programs to raise community awareness of preventable major health hazards
10. Sustainable tourism activities in the coastal areas, and relocation of vulnerable communities from low-lying areas
11. Enhanced wildlife extension services and assistance to rural communities in managing wildlife resources
12. Water harvesting and recycling
13. Artificial structures, such as sea walls; re-sanding beaches; and coastal drainage and beach management systems
14. Improved land tenure systems; sustainable human settlements
Emerging Climate Change Adaptation Strategies Around the World

BANGLADESH: DISASTER CONTROL
WITH LIMITED MEANS

Summary
Bangladesh is one of the countries that will be most affected by climate change. Two-thirds of the country is located in low-lying coastal wetlands less than five meters above sea level, so rising sea levels pose an especially serious threat. In the past, Bangladesh has frequently been hit by natural disasters, and climate change threatens to make such catastrophes even more common. Despite its financial constraints, the country is trying to prepare for these enormous threats as much as possible, to minimize both the number of potential victims and the economic impacts. In this regard, Bangladesh’s case offers some best practices. For instance, in the event of an imminent flood, the population is alerted through an early warning system that uses volunteers to alert people via megaphones as well as over the radio. Given the massive threats and its limited financial means, Bangladesh depends on international support for its measures to adapt to climate change.

Country Profile
Bangladesh has one of the largest river deltas in the world. This delta is formed by the rivers of the Ganges, Brahmaputra, and Meghna, and encompasses a network of 230 rivers, including tributaries and branches. Bangladesh is a very fertile country with rich water resources. However, due to the delta, sea water often moves far into the mainland. Therefore, a minimal rise of the sea level has serious consequences for the population located in the south of the country, which consists mainly of peasants. According to estimates, a rise in sea level of 1.5 meters would affect 15 million people in southern Bangladesh. Under this scenario, 22,000 square kilometers of land, or 16 percent of the country, would be lost to the sea.

Bangladesh is one of the countries most affected by natural disasters. Besides floods, the country is regularly hit by tropical storms, droughts, earthquakes, and mud slides caused by erosion. Such natural disasters are expected to intensify as a result of climate change.

About one forth of the gross domestic product of Bangladesh is produced by agriculture. As a result, climate change and rising sea levels can cause significant economic losses. The livelihood of many of those who rely on subsistence agriculture is at risk. The production of rice could fall by 10 percent by 2050, and overall crop production could fall by 32 percent during the same period, because of the loss of arable land through salt water contamination.

Strategy and Actors
Although Bangladesh is among the least developed countries in the world, the country has developed good adaptation approaches, especially in the field of disaster management. Bangladesh has always had to fight floods and other natural disasters; therefore, despite limited resources it has developed a comprehensive system in order to handle these threats. However, unlike countries such as the Netherlands, Bangladesh cannot protect the whole population from the consequences of climate change. The goal is rather to minimize the impacts on people and the economy.

The most important natural disaster program is the Comprehensive Disaster Management Programme (CDMP), initiated by the government in 2003. CDMP is a comprehensive program that aims to limit the long-term risks and to build operative capacities in the field of disaster control. It also deals with many of the main adaptation challenges. The
Floating Houses and Mosquito Nets:

The CDMP program is supported both by UNDP and by the British development organization Department for International Development (DFID). The CDMP also includes central guidelines and strategies for the Ministry of Food and Disaster Management (MoFDM), established in 2003. In addition to the steering committee, which is the central decision-making body, there is the Program, Policy and Partnership Development Unit (PPPDU), tasked with coordinating the different actors involved, as well as with mainstreaming disaster control and development policy.

The CDMP is complemented by UNDP’s Participatory Disaster Management Programme (PDMP), which also serves other Asian countries. In Bangladesh, the program targets the most urgent measures with a short-term implementation horizon. It is an action- and project-based addition to CDMP’s strategy, focusing on simple preventive measures and on handling the consequences of natural disasters. Action plans are developed in cooperation with the most important stakeholders in the region. Other measures include the training of catastrophe management staff, the implementation of local risk reduction concepts, and the establishment of early warning systems.

In 2005, Bangladesh also developed a National Adaptation Programme of Action (NAPA) within the framework of the UNFCCC. The preparation process was handled by a steering committee of representatives of the most important ministries. The Ministry of Environment and Forest (MoEF) leads the project. During the development of the plan, strategy workshops with affected stakeholders were organized, and NGOs and academics were involved in the process. The plan identifies the most important vulnerabilities, and recommends a comprehensive catalog of prioritized measures. The 15 most important measures are accompanied by a specific project.

One priority is the reforestation of the coast line, to be done in cooperation with the local population. This measure alone will cost 23 million US dollars. Other priorities include: raising awareness regarding preventive measures among affected groups of the population; the adaptation of agriculture in areas threatened by floods; protective building measures against floods; and repairs of significant damages. Additional projects concern coastal water supply, insurance options, and other emergency provisions. There are also research and educational initiatives.176

While disaster control is managed by the Ministry of Food and Disaster Management, the Ministry of Environment and Forest (MoEF) is responsible for the planning of the remaining adaptation policies. The Department of Environment within the MoEF is tasked with the implementation measures. The main goals are to integrate adaptation policies into urban and building development policies, to educate the public, and to facilitate the spread of knowledge on the impacts of climate change in Bangladesh.

Because of the country’s high vulnerability, many international actors are engaged in Bangladesh. The United Nations has written elaborate studies on adaptation in Bangladesh, and finances many local projects. Additionally, many na-
tional governments are engaged. For instance, the British Department for International Development (DFID) contributes to the construction of flood-resistant housing. The Netherlands is also active in the country, especially regarding coastal protection measures.

Bangladesh has also been involved in the international debate on adaptation policy. The country regularly calls for international support for the massive efforts that are needed in order to adapt Bangladesh to the impacts of climate change. Bangladesh also proposed the creation of an adaptation fund for southern Asia within the framework of the South Asian Association for Regional Cooperation (SAARC). Furthermore, as a Least Developed Country (LDC), Bangladesh is an alternating member in the council of the adaptation fund of the UNFCCC.

Information

Compared to other developing countries, Bangladesh possesses a well-functioning data collection system. Although there is still a great need for research on the long-term consequences of global warming, especially regarding forecasts and monitoring, activities are already well established. For instance, the Flood Forecasting and Warning Centre (FFWC), founded in 1972, consists of a network of 52 observation wards with the responsibility to analyze and report on various watersheds. Additionally, the observation wards publish forecasts 24, 48 and 72 hours ahead. The network covers most of the flood-threatened regions in Bangladesh. The FFWC is crucial for the adaptation strategy in Bangladesh, especially with regard to problems in water resource management. The Cyclone Preparedness Programme and the Bangladesh Meteorological Department are also active in the field of forecasting and monitoring.

Communication and Education

Informing the population about weather extremes and possible protective measures is crucial to saving lives in Bangladesh. Therefore, the country is already implementing several initiatives. The Disaster Management Information Center (DMIC) is a central platform at the interface of academia and policy-making. It is responsible for information strategy for catastrophe management. The center collects relevant information in the field of disaster control and provides various actors with the data. The Disaster Management Information Network (DMIN) is intended to link the DMIC with government, NGOs, and threatened local communities. The goal is to establish an efficient and stable infrastructure that provides affected people and relief workers with information on imminent threats, as well as with behavioral guidelines for emergencies.

Another important initiative is the Climate Change Cell, an alliance of CDMP, UNDP, DFID and the European Commission. The goal is to inform citizens about climate risks, and to help them handle these dangers. It also aims to link poverty reduction with climate change adaptation measures. The Ministry of Environment and Forest manages the process. One of the initiatives is the Grass Root Awareness Initiative, an outreach program that has the goal of meeting the direct needs of affected municipalities. The initiative aims to help affected communities detect risks and develop preventive measures.
India: The Water Challenge

Summary
Despite dramatic economic growth over the last decade in India, most of the population still depends to a great extent on agriculture. This makes the country highly vulnerable to the impacts of climate change, which will only further aggravate the pressure put on natural resources. In addition, fresh water supplies are especially at risk. In the context of these threats, the government began to address the potential impacts of climate change and to consider appropriate adaptation measures. Numerous research programs have been launched, and some concrete adaptation projects have already been implemented. Furthermore, adaptation measures have been gradually integrated into the overall planning process. In June 2008, the Climate Council of the Prime Minister passed the National Action Plan on Climate Change (NAPCC), which outlines the major threats for India and proposes an adaptation strategy with concrete measures. The respective ministries have been tasked with working out the details.

Country Profile
Currently, India has a population of 1.1 billion people, which represents 17 percent of the world population. 70 percent of the population lives in rural areas, where poverty is most prevalent: about three-fourths of poor Indians live in rural areas. India has very high population density; however, the population is very unequally distributed and is concentrated in the fertile plains along the rivers and along the coastline. These are the same areas which are expected to be most affected by climate change.

Global warming will particularly impact Indian water supply. A large amount of the demand for water is met by rainwater during the monsoon season. Due to the heavy contamination of many rivers, monsoon rains are the only clean water source in many parts of India. Therefore, even minimal changes in the patterns of the monsoon rains have serious consequences for the people and the overall economy. During the dry season, the population is highly dependent on stored monsoon rainwater. Recently, the patterns of the monsoon rains have changed significantly. Northwest India has been increasingly affected by heavy rainfalls, while rainfall amounts have fallen in east India. Overall, the amount of precipitation is decreasing. In November 2007, the monsoon provided much less rainfall than needed, yet soon thereafter heavy rainfalls caused large parts of India to fight massive flooding. Another significant water resource comes from annual snow and glacial melt from the Himalayas. These melt waters feed the Ganges and other rivers in India. However, these glaciers are retreating at increasing rates. According to experts, they might disappear completely by 2035. This has serious consequences for the living conditions of people who live along the river banks, as well as those who depend on the water flows and the electricity produced by hydropower stations.

Climate change is expected to increase the frequency of floods, and rising sea levels threaten the population along the coast. Already, many inhabitants of small islands in the mangrove forests of the Sundarban (an estuary of the Ganges) have had to be relocated.

Despite the fast growth of other sectors of the Indian economy, agriculture still produces 18.5 percent of the gross domestic product. Almost two-thirds of the population depends on agriculture, many of them at subsistence level. As a result, the consequences of global warming for agriculture and the poor rural populations are serious challenges in India. 60 percent of the agricultural areas in India are irrigated with rainwater, making these areas especially vulnerable to changing patterns of precipitation. Decreasing amounts of rainfall lead to reduced production levels, threatening the livelihood of rural populations. The problem of water scarcity is further aggravated by a lack of sufficient storage capacities for rainwater. While China is able to store 1,000 cubic meters...
of water per inhabitant, and Morocco 5,000 cubic meters, India only has capacity for 200 cubic meters.\textsuperscript{189}

The rise of temperatures has the potential to cause serious public health problems in India. Besides the spread of gastrointestinal disorders, experts also warn of an increasing prevalence of malaria. Extreme heat waves can raise the number of heat-related casualties, especially among sick and elderly populations. The danger from other extreme weather events increases as temperatures rise.

Strategy and Actors
India was an early adopter of the climate change adaptation and awareness strategies. It has also fostered the debate on global warming in international politics. For instance, during the conference of the signatory states of the United Nations Framework Convention on Climate Change, held in Delhi in 2002, India pushed for a joint declaration on the significance of global warming. The Indian report to the UNFCCC also emphasizes the need to assess vulnerabilities and to plan adaptation measures.\textsuperscript{190}

In June 2008, India’s prime minister published the National Action Plan on Climate Change (NAPCC), which encompasses both climate protection and adaptation.\textsuperscript{191} The plan defines eight priorities as National Missions: solar energy; energy efficiency; sustainable housing; water; preservation of ecosystem in the Himalayas; reforestation; sustainable agriculture; and strategic knowledge management. The responsible ministries are currently working on detailed implementation plans for these eight sectors.\textsuperscript{192}

Adaptation measures are an important part of this integrated climate strategy. The first two areas (solar energy and energy efficiency) are mainly focused on climate protection, while the others include adaptation components, especially in the cases of agriculture and of knowledge management. What follows is a summary of the adaptation goals.

This summary shows that the Indian government has already set strategic adaptation priorities. However, detailed planning and implementation of the measures is only just beginning.

<table>
<thead>
<tr>
<th>National Mission</th>
<th>Adaptation measures</th>
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<tbody>
<tr>
<td>National Mission on Sustainable Habitat</td>
<td>The goals are to foster energy efficiency, the use of reusable materials, and to improve urban planning. Other priorities are the protection against extreme weather events through early warning systems, intelligent planning, and disaster control.</td>
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<tr>
<td>National Water Mission</td>
<td>The goal is to make the use of water more efficient, to secure the water supply despite the increasing scarcity associated with climate change.</td>
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<tr>
<td>National Mission for Sustaining the Himalayan Ecosystem</td>
<td>In order to protect ecosystems in the Himalayas, the government plans to increase the protection of biodiversity, forests, and glaciers.</td>
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<tr>
<td>National Mission for a “Green India”</td>
<td>The goal is to plant new trees and to reforest an area of six million hectares, which will increase forest area from 22 to 33 percent.</td>
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<tr>
<td>National Mission for Sustainable Agriculture</td>
<td>The goals are the development of resilient crops, a wider use of weather insurance, and more sustainable cultivation methods.</td>
</tr>
<tr>
<td>National Mission on Strategic Knowledge for Climate Change</td>
<td>The government aims to improve the understanding of climatic processes. The goal is to develop more precise models and to foster international exchange. Additional goals are to facilitate access to relevant data and to involve the private sector more systematically than before, especially the insurance industry.</td>
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In conjunction with the publication of the national action plan in June 2008, a climate council was established. The climate council is responsible for the coordination of national efforts. It consists of representatives from ministries, academia and civil society. The Ministry of Environment and Forests directs the adaptation strategy, which cooperates with other ministries depending on the National Mission. Other ministries also have their own adaptation initiatives. For instance, the Ministry of Agriculture has created a department to help incorporate climate impacts into agricultural policies and programs.

India links adaptation measures with its more general development efforts. Indian government officials regard anti-poverty programs as the best adaptation strategy. Although this approach is based on a very broad definition of adaptation, it does justice to the situation in many emerging markets and developing countries. Such countries can only improve their ability to adapt to global warming if overall poverty levels and the vulnerability of the population are reduced. These combined efforts explain the significant expenses India has put towards climate change adaptation measures. According to the Ministry of Environment and Forests, in 2006/2007, India spent 11 percent of its national budget and over two percent of its gross domestic product on adaptation measures. The majority of these expenses (75 percent) were for poverty-reduction measures. Other areas involve the improvement of agricultural productivity, protection against droughts, catastrophe management, health provisions, and the preservation of natural resources.

To ensure the long-term sustainability of anti-poverty measures, it is important that investments incorporate uncertainties about future climate impacts. India tries to handle this difficult challenge in a number of ways. For example, in some Indian states, the Indian National Bank for Agriculture and Rural Development (NABARD) cooperates with the German Gesellschaft für Technische Zusammenarbeit (GTZ) to incorporate the impacts of climate change into development programs for rural areas.

In India, not only the government, but also actors from civil society and NGOs, are engaged in climate adaptation. An important nonprofit organization is Winrock International India. This think tank works on risk assessments and adaptation strategies for droughts, cyclones, and floods, as well as disaster control measures. Winrock International India has made important contributions to national reports for the UNFCCC, and the organization was a member of the Indian team within the BASIC project (see project case studies). Another important actor is the Energy and Resources Institute (TERI), which is currently studying the consequences and dangers of climate exchange in the northeast of India. TERI is commissioned by the Ministry of Environment and Forests. Since 2002, the director of TERI, Dr. Rajendra Kumar Pachauri, has been the chairman of the Intergovernmental Panel on Climate Change (IPCC), which was awarded the Nobel Peace Prize in 2007.

International organizations and foreign governments also contribute to Indian adaptation efforts. The British Department for International Development (DFID) implements a range of regional programs to improve the adaptation capacity of rural populations and to protect against climate-related natural disasters. The German GTZ implements rural water projects (see project case studies). The GTZ also works on technical solutions in the fields of forestry and water management, and supports the micro-insurance industry.

Information
India has been funding research on climate impacts for many years, and has a well-established data base. Many research initiatives have been linked to work done for the first national report for UNFCCC, published in 2004. Ministries have also initiated sector-specific research projects on the impacts of climate change. Nevertheless, there are still significant research gaps in India, especially concerning regional and local climate projections.

Communication and Education
The Indian government has many years of experience communicating environmental issues and the related outreach activities needed to raise awareness among the public. During work on the first national report for the UNFCCC, Ministries, NGOs and research institutes were involved in more than 20 workshops and seminars. An important question discussed during this process was how to develop an integrated approach to climate protection and adaptation. An internet platform was created for this process, and results of the workshops have been published, connecting the various stakeholders.
CHINA: ADAPTATION OF AGRICULTURE AND WATER RESOURCE MANAGEMENT

Summary
In China agriculture and the water supply will be particularly affected by climate change. Water will probably become scarce in many parts of the country, threatening rural and subsistence agricultural production. In addition, most of China’s big cities and economic centers are located along the coast, and are therefore threatened by rising sea levels. The most recent national climate program from 2007 addressed needed adaptation measures. Additionally, a white paper on climate change was published in October 2008, outlining concrete goals for adaptation measures that must be met by 2010. Besides important infrastructure projects proposed for the water sector, the white paper also announced a redoubling of efforts to protect the environment. These developments show that adaptation has gained in importance on the Chinese political agenda.

Country Profile
Climate change represents a serious challenge for China, especially for agriculture and water supply. The climate impacts on water resources differ significantly between different regions: In northern China the outflow of watercourses is expected to decrease, while it is expected to increase in southern China. This in turn means that the occurrence of floods and droughts will also increase, and will put the stability of the nation’s water supply at risk. The accelerating melting of the Himalaya glaciers, in particular, could cause massive problems. These glaciers play an important function for water supply in Asia. In China, the Himalayas feed both the Mekong and Yangtze rivers. However, they are melting faster than glaciers in other regions of the world. If melting processes continue at current rates, it is expected that the Himalaya glaciers will disappear completely by 2035. Although the outflow of water will increase early on in the process, it will decrease substantially as the glaciers continue to shrink. The consequences to the Chinese water supply would be devastating, because 250 million people depend on melt water from the Himalayas.

In the case of agriculture, global warming has the potential to reduce the productivity level of crops, which means that the food supply for the population is at risk. By 2030, crop production might fall between five and 10 percent. In the second half of the 21st century, it might even fall by 37 percent (for rice, corn and wheat) if no adaptation measures are taken. Due to the increased evaporation in many regions and the decreasing rainfall, the need for artificial irrigation will rise. In semiarid regions of China the process of desertification will accelerate. In the mountains, the climate line for grassland will move higher in elevation. However, in the case of forestry, climate change might lead to an increase of productivity of one to 10 percent by 2030, mainly in the northwest part China.

Due to rising sea levels, coastal regions are threatened by increased flooding. China is particularly vulnerable in this regard because 70 percent of the largest cities are located along the coast. These cities are the economic powerhouses of the country, producing a large part of the Chinese gross domestic product. More than 130 million people live near the coast or on low-lying islands. A 30 cm rise in sea level would result in 80,000 square kilometers of coastal lowlands in China being flooded.

As in other countries, climate change affects public health, due to the rising frequency of heat waves and the spread of infectious diseases. Diseases like malaria and dengue fever are expected to become more prevalent.

Strategy and Actors
In June 2007, China passed a national climate program, which includes adaptation measures. The focus lies on agriculture, forest and ecosystems, water resources, and coasts.
report emphasizes the need to develop new technologies to increase the capacity for adaptation in the above-mentioned sectors. The report announces massive infrastructure projects, such as dams and water supply systems, but also includes measures for environmental protection. Here are some examples:

**Agriculture**
- Improving agricultural infrastructure by developing more effective large-scale irrigation.
- Fostering the adaptation of agricultural and cultivation systems by optimizing the selection of arable land and by diversifying the kinds of crops that are cultivated.
- Cultivating species resistant to global warming-related stresses, such as droughts, stagnant moisture, higher temperatures, and insect infestation.
- Preventing desertification in the steppe by monitoring grazing intensity.
- Intensifying research and development in biotechnology as well as in high-precision cultivation and the prevention of crop epidemics.

**Forests and other Ecosystems**
- Improving the protection of forests and other ecosystems, by implementing a strict control system for logging as well as by extending and improving nature reserves.
- Strengthening research and development of new technologies for the fight against forest fires and pests, the protection of biodiversity, and the cultivation of more drought- and pest-resistant tree species.

**Water**
- Improving the management of water resources, developing national systems for water use rights, and implementing water-saving measures.
- Accelerating the planning and construction of infrastructure; one example is the South-to-North Water Diversion project, the largest water supply project in the world. The project is intended to secure water supply to the north of China.
- Developing and improving technologies for the distribution, storage, and use of water.

**Coastal Zones and Coastal regions**
- Developing and improving relevant laws and regulations by establishing integrated coastal management systems.
- Developing and improving technologies for the protection and revitalization of maritime ecosystems, especially mangrove forests, coral reefs and coastal wetlands.
- Improving environmental monitoring and early warning systems by building new observation wards.
- Strengthening adaptation strategies for rising sea levels, including dam and dike construction and the prevention of ground water exploitation in coastal regions.

In October 2008, the Chinese government also published a white paper on climate change adaptation strategies, which specifies China’s adaptation plans.201 The document includes goals for the year 2010, such as:
- Finishing a series of building projects for the protection against extreme weather events.
- Restoring 52 million hectares of steppe, which are affected by desertification.
- Extending nature reserves until they represent 16 percent of China’s land area.
- Restoring 250,000 square kilometers of land that has suffered from soil erosion.
- Realizing progress towards more efficient water use, restoration of mangrove forests and coastal protection.

These planning processes tie in with measures that have already been initiated or implemented, including water resources (water storage projects to prevent floods), agriculture (selection, cultivation, and distribution of more resistant plants) and coastal zones (the creation of ocean protection zones).202

Climate policy has recently gained more importance in China, and this has been reflected in institutional changes. In 1998, the National Coordination Committee on Climate Change was established in order to coordinate cross-sectoral climate policy. This committee was transformed into the National Leading Group to Address Climate Change in 2007. Chaired by the Chinese prime minister, the group coordinates climate-relevant strategies, programs, and measures. Since 2008 the group has been linked to the National Development and Reform Commission.203 This exemplifies how climate policy is seen as closely related to China’s economic development. However, due to China’s political system, the influence of NGOs and the media is low.204
Nonetheless, Chinese national authority has only limited influence on the local level. Climate and environmental issues are often neglected due to a lack of incentives and the prioritization of economic development. However, a process of rethinking has begun: according to experts, the Chinese government is realizing that the sustainable use of resources has to be implemented at a local level. Therefore, the national government is changing the incentive structures for municipal governments regarding the protection of natural resources. Some of the more wealthy coastal provinces have already invested in coastal protection measures, independent from the central government.

Information
China has produced a series of analyses on the impacts of climate change over the past few years. In 2006, after four years of work, the Chinese government published the National Assessment Report on Climate Change. More than twenty government institutions contributed to the report. The impacts of climate change in China, and possible adaptation measures, are very prominent in the report, which was used as the foundation for subsequent planning processes.

Recently, the government has increased funding for research on the consequences of global warming and the development of adaptation measures. The goal is to develop impact scenarios, especially in the case of agricultural productivity. The Chinese Academy of Agricultural Sciences (CAAS) plays an important role in this regard. The Agro-Meteorological Institute of the CAAS (AMI) does research on adaptation to climate change, biodiversity, and land degradation. One goal is to develop technologies for minimizing the impacts of droughts and other extreme weather events.

Communication and Education
Due to the political system, there is a lack of open public debate about environmental issues in China. However, the government has implemented some communication measures to inform the population about the risks of climate change. For example, the government publishes risk maps that include information about areas threatened by flooding. These maps focus on river basins with high population density and high flood risk. The maps can be used for land use planning, and also include information about emergency measures in case of flooding.
Country Profile
Climate change will affect Brazil in multiple ways. The consequences of global warming can already be observed today. During the past decades, patterns of precipitation have changed significantly and temperatures have risen by 0.5°C.206

The Amazon region is especially vulnerable to climate change. The Amazon is the largest rainforest in the world and represents 40 percent of all remaining rainforest on the planet.207 About 65 percent of the Amazon region is located in Brazil. The remainder is distributed across eight additional countries. The Amazon region is crucial for both the global and the local climate. Through evaporation, the rainforest absorb massive amounts of heat and is an important source of fresh water. About half of all rainfall in the Amazon region is caused by local evaporation. Furthermore, the most important export-oriented agricultural regions of Brazil are dependent on the Amazon water cycle, and given its role as a huge CO₂ sink, the Amazon region serves a key function in the global climate systems.

It has long been known that massive clear-cutting operations represent a serious threat to the Amazon rainforest. The fact that the tropical rainforest is also threatened by the impacts of climate change is less known.208 Temperatures and rainfall amounts are expected to become more volatile in the future. Furthermore, a global average temperature increase of 2°C could result in a local temperature rise of up to 4°C. This problem, and the rising frequency of extreme weather events, could overburden the natural adaptive capacity of the rainforest, leading parts of the rainforest to be transformed into savannahs.209

Sustainable Forest Management is a Win-Win Solution
Sustainable forest management is a win-win solution, which both protects the climate and serves as a climate change adaptation strategy. On the one hand, the tropical rainforest is threatened by deforestation. On the other hand, the consequences of climate change strain the ecosystem of the rainforest. Therefore, measures that protect the rainforest from deforestation and degradation, and make the forest more resilient to climate impacts, contribute to both goals. However, to date climate change impacts have not been sufficiently considered. Possible measures that would increase the adaptive capacity of the rainforest include: improving the integrity of the ecosystem; sustainable cultivation methods; the prevention of forest fires, and more effective fire-fighting methods.

Source
Furthermore, climate change and deforestation are linked as higher temperatures increase evaporation, leading in turn to droughts and an increase in frequency of forest fires. In 2005, there was a drought in the Amazon region, which was possibly linked to increased surface temperatures in the tropical North Atlantic. Before then, droughts were inconceivable in this high rainfall region.

Climate change will probably also result in health risks for the Brazilian population. Increases in temperatures allow disease vectors to spread more easily, and lead to an increase in the prevalence of mosquito-borne diseases like dengue fever and malaria. Increased frequencies of droughts present serious problems for agriculture, especially in the arid northeast parts of the country.

Brazil’s energy supply will also be affected by climate change; over two-thirds of energy demand in Brazil is met via hydropower. The drought of 2001, combined with an increase in energy demand, caused shortages of hydropower production and serious economic damage.

Brazil has also been frequently hard-hit by extreme weather events. In 2004, a hurricane hit the southeast of Brazil, the first observed cyclone in the southern Atlantic Ocean to reach the strength of a hurricane. It destroyed more than 3,000 homes and caused massive floods. Researchers at the Brazilian National Institute for Space Research concluded that the emergence of the hurricane was linked to global warming.

Strategy and Actors

In the past, climate change adaptation has been neglected by most South American countries. However, this has started to change in recent years, and Brazil is beginning to evaluate and study the impacts of global warming in greater depth.

In December 2008, a new national climate plan was presented, which deals with both climate protection and adaptation. Thirteen different Brazilian ministries worked on the plan. Additionally, the Brazilian Forum on Climate Change, an umbrella organization, which aims to raise the awareness and foster the debate on climate change, contributed to the plan. The plan includes 100 recommendations for climate protection and adaptation.

Regarding adaptation, the plan highlights that there is still not enough information on regional impacts of climate change in Brazil. Therefore, the goal is to publish more exact regional scenarios by the end of 2009. The development of better methods and expertise for regional climate model, as well as the improvement of the data on vulnerabilities in different regions, are priorities. Once better regional scenarios are available, the planning of adaptation measures will be intensified.

The Amazon Fund

The new Brazilian climate strategy includes an important reforestation program announced by President Luiz Inácio Lula da Silva in the summer of 2008. By the year 2021, the Amazon Fund plans to invest 21 billion US dollars in the protection of the rainforest. Specific goals of the fund include:

- Extending natural reserves and state-owned rainforest
- Environmental monitoring and control
- Fighting illegal logging and poaching
- Sustainable forest management
- Protection of biodiversity
- Reforestation and revitalization of the forest ecosystem
- Funding environmental services

Up to 20 percent of the fund will be invested in the transfer of knowledge and technology to other countries with tropical rainforests.

The Amazon Fund could contribute to both climate protection and to climate adaptation projects. The goal is to finance the fund—which is managed by the Brazilian Development Bank (BNDES)—with the support of international donors. This represents an important change for Brazil’s forest policy. Traditionally, Brazil was committed to finance the protection of the Amazon region on its own; the fund therefore represents a step in a new direction, and demonstrates Brazil’s recognition of the global importance of the Amazon. Norway has already agreed to contribute up to 100 million dollars annually over the next five years, depending on the progress of the protection measures. Brazil intends to decide on its own how the money is used, and therefore most foreign donors will not have a say in how Amazon Fund dollars are spent. The project plan does stipulate, however, that NGOs, researchers, and state governments can propose projects for the Amazon region.
The plan also emphasizes that anti-poverty measures and economic development, in general, help increase resilience against climate change impacts, since poor populations are especially vulnerable to impacts of climate change.

The plan details adaptation measures that Brazil has already began implementing. For example, in 2004 the Ministry for the Environment launched a program that fights desertification and reduces the negative impacts of droughts (PAN Brasil – Programa de Ação Nacional de Combate à Desertificação e Mitigação dos Efeitos da Seca). Another example is the initiative for sustainable water management in the region of Rio de la Plata, which will be particularly affected by climate change. The initiative is carried out in cooperation with Argentina, Bolivia, Paraguay and Uruguay. Goals are to improve environmental monitoring in the region and to foster the exchange of information among countries.

Information
Brazil has better climate research capacities than most South American countries. Brazil’s Brazilian Center of Weather Forecasting and Climate Studies (CPTEC), located at the National Institute for Space Research (INPE), is one of the few South American research institutions in a position to develop regional climate projections. For example, CPTEC is responsible for the launch of a new initiative, Regional Climate Change Scenarios for South America (CREAS). The goal of the project is to provide climate scenarios for the three most densely populated river basins in South America, to inform governments and political decision-makers about the impacts of climate change and possible adaptation strategies. At the moment, better regional models are being developed in order to create a baseline for further planning and specific adaptation measures. The models are to be published in 2009.
## CASE STUDIES COLLECTION

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Regions and Cities Cooperate Through the ASTRA project

Between 2005 and 2007, the ASTRA Project (Developing Policies & Adaptation Strategies for Climate Change in the Baltic Sea Region) focused on the development of adaptation strategies in the Baltic Sea area. Based on current scientific results, the project developed regional climate impact scenarios and informed local decision-makers about needed adaptation measures. Project partners included cities (Helsinki, Kokkola, Loviisa, Epsoo, and Raahe), regional councils, environmental centers, companies, and the Finnish association of local and regional authorities.

One result of the project was the implementation of flood protection measures in two Finnish cities. Land parcels open for building projects in the city of Espoo will now have to be at least 3 meters above sea level. In Kokkola (western Finland), the requirement is 2.5 meters. In order to protect already endangered houses, individual solutions have been developed with property owners (such as artificial elevation and dams).

Source

ASTRA-Project: www.gsf.fi/projects/astra

Research on Adaptation to Climate Change in Agriculture (ILMASOPU)

Climate change might be an opportunity for Finnish agriculture. However, this will only be the case if proper preparations and adaptations are undertaken. Therefore, in 2006 the Finish Ministry of Agriculture initiated the research project ILMASOPU. For three years, ending in 2009, the project will analyze how climate change will affect individual sectors of production, and how agriculture can be adapted to the new circumstances in due time. The changes in the international supply and demand for agricultural products due to climate change will also be incorporated into the analysis.

The goal of the project is to develop a comprehensive regional projection of Finland’s agricultural production capacity and competitiveness. The projections are intended to help private and public decision-makers incorporate the impacts of climate change into their strategic planning processes.

Sources

Ministry of Agriculture and Forestry: http://www.mmm.fi

Northern Finland: Adaptation of tourism to climate change

Finnish tourism also has to prepare for the consequences of climate change. Temperature shifts offer the opportunity to extend summer tourism in the south while the preservation of winter and ski tourism in the north presents a difficult challenge.

The city plans for Rovaniemi, Kolari, and Kittilä, and plans for the winter sports regions of Ylläs and Levi, call for ski areas threatened by rising temperatures to be artificially supplemented with snow cannons. Alternative sports and leisure activities will also be offered. New ski resorts could be established in the northern regions that have not been seriously affected by snow melt.

Sources

System for the Management of Flood Risks

The Flood Information System project is dedicated to forecasting the risks of flooding. It uses computer-based geographic information systems (GIS), analyzing the Kemijoki und Ounasjoki rivers as case studies.

The aims of the project are to develop plans for managing regional flood risks and to formulate recommendations for building standards and land use planning. The results are taught in seminars and circulated on the internet and other media to reach the local public.

Sources
- 7th International Conference on Hydroinformatics:
  http://www.ymparisto.fi/download.asp?contentid=62697&lan=en
- Water Information System for Europe:
FRANCE: PROJECT CASE STUDIES

The Paris Heat Wave Strategy

Heat waves during the summer months present health risks especially for the elderly, people with lung and cardiovascular diseases, and small children. In 2004, the city of Paris presented its own heat wave plan under the slogan Protection Against Heat Waves, concentrating on the needs of the elderly and disabled in Paris and the surrounding areas. The new plan has the goal of preventing the high rate of casualties that the city experienced in August 2003, when 15,000 people, mostly elderly, died from causes associated with extreme heat.

The emergency plan requires the city to extend support to nursing homes, hospitals, and home care services. Along with better insulation of apartments and buildings, the plan focuses on the establishment of emergency and support centers. The multi-level plan also envisages that in case of extreme temperatures affected people are directly contacted by city hall in order to assess their health status. A social service organization is created with the responsibility of sending social workers for house calls in all parts of the city during heat waves.

Source


Club ViTeCC: Initiative for linking cities and municipalities

The Club of French Decision-Makers Club ViTeCC (Club Villes, Territoires et Changement Climatique) fosters new links among local decision-makers, land use planners, climate experts, and companies from the energy, construction, water, transport, and financial sectors. The club aims to improve preparation for the impacts of climate change and to foster climate protection. Adaptation initiatives focus mainly on expected damage to infrastructure. Specific recommendations will be formulated in 2009.

The club was launched in January 2008 following a symposium on adaptation to climate change in Paris. The research center Mission Climat of the Caisse des Dépôts, the National Observatory on the Effects of Global Warming (ONERC – Observatoire National sur les Effets du Réchauffement Climatique), and the French weather service Météo France are among the founders.

The participants meet quarterly; topics covered have included “Energy and Climate Risks,” “Flooding,” and “Global Climate Challenges.”

Source

- APREC: http://www.aprec.net/uk_adaptation.php

ClimChAlp: The Impacts of climate change in the Alps

Climate change presents great challenges for the ecosystem of the Alps. Initiated in 2006, the project ClimChAlp (Climate Change and the Alpine Space) had the goal of helping ecosystems and people handle the impacts of climate change. Ministries, authorities, and researchers from seven Alpine countries cooperated very closely for two years, to find a common approach for addressing the challenges of climate change and formulating basic principles for adaptation strategies. The project focused on the areas of natural disasters, risk management, regional development and the economy. The task force recommended increasing cross-border cooperation in the Alpine region, improving climate change projections, developing an international terminology for risk assessment, as well as coordination of these efforts.
The Bavarian Ministry for the Environment, Health and Consumer Protection initiated the project. In France, coordination of the French region of the Alps was organized by ONERC, the Environment and Energy Authority of the Rhone Alps, and Claude Bernard University in Lyon. In the beginning of 2006, the project was approved within the framework of the EU initiative Interreg III B Alpine Region. The initial budget was approximately 3.5 million euros.

Source
**GERMANY: PROJECT CASE STUDIES**

**KLIWA: Water adaptation strategies in southern Germany**

To prevent flooding in Southern Germany, the states of Bavaria and Baden-Württemberg, along with the German weather service, analyze the impacts of climate change on their water sector through a joint project, KLIWA. In 2007, the state of Rhineland-Palatinate joined the project.

The goal of the initiative is to develop recommendations for specific regions based on climate and water budgeting models. These models can help integrate needed adaptation measures into the planning process of water-related construction. Initial studies from the interdisciplinary cooperative project in 1999 predicted that by 2050, the risk of serious, hundred-year floods will rise by 15%. The frequency of small and medium flood events will rise by up to 80%. These statistics make clear the important challenges facing the water sector, which are to be handled by bundling competencies and resources. For instance, flood protection systems are built assuming water levels that are 15% above today’s levels, or are designed in such a way that the systems can be retrofit at a manageable cost.

Additional analyses focus on efficient water use, drainage, and ground water recharge. Internet platforms, conferences, and brochures are used to inform citizens, academics, and policy-makers about regional climate impacts and local adaptation options.

*Source*

- Climate change and the water economy: [http://www.kliwa.de/](http://www.kliwa.de/)

**Munich Climate Insurance Initiative: Insuring against extreme weather events**

In Germany, private companies have also launched adaptation projects in response to climate change. In 2005, the insurance company Munich Re started the Munich Climate Insurance Initiative. The goal of the initiative is to develop innovative insurance solutions (such as new forms of micro-insurance) for extreme weather events, particularly in developing countries.

The initiative is supported by companies, NGOs, and research institutes. Project partners include: the Potsdam-Institut für Klimafolgenforschung (PIK); Germanwatch; the International Institute for System Analysis (IIASA); Munich Re and the Munich Re Foundation; the Energy and Resources Institute (TERI); the Tyndall Centre for Climate Change Research; the United Nations Framework Convention on Climate Change (UNFCCC); the World Bank; and the World Meteorological Organization (WMO).

*Source*

- Munich Climate Insurance Initiative: [www.climate-insurance.org](http://www.climate-insurance.org)

**Climate Plus: Innovative project ideas from North Rhine-Westphalia (NRW)**

In May 2008, the support program Action Climate Plus – NRW Climate Municipality of the Future was launched with a state-wide call for proposals from the Ministry for the Environment of North Rhine-Westphalia. Using a competitive process, the Ministry invited nominations from any rural municipality addressing both climate protection and adaptation to the consequences of climate change. and could therefore be considered a role model in its approach to climate change.

The competition consisted of two parts: First, 54 cities and municipalities participated in the call for proposals, submitting
climate concept statements and project plans for concrete measures. Five municipalities qualified for the second part of the competition, in which they had to elaborate on their proposals. In spring 2009, the jury selected the City of Bocholt and the Municipality of Saebeck as the winners. Both convinced the jury with a sound, comprehensive local plan. The City of Bocholt, with almost 74,000 inhabitants, regards reducing heat use in residential and commercial buildings and alternative transport programs as the most promising measures to reduce CO₂ emissions. Saerbeck aims to achieve a positive energy balance and to offset all municipal fossil CO₂ emissions with alternative energy by 2030.

The winning communities were awarded a total of 3 million euros over a period of four to five years. The money will not only fund technical solutions, such as the adoption of alternative energy and flood protection, but also will finance citizen participation and awareness-raising projects. The NRW Climate Municipality of the Future is intended to serve as a role model for other communities, especially with regard to the feasibility of an approach that integrates climate protection and adaptation to climate change.

Source

Administrative Alliance: Adaptation of disaster control to climate change

In June 2007, the Federal Office of Civil Protection and Disaster Assistance (BBK) initiated an administrative alliance among the Federal Environmental Agency, the Federal Agency for Technical Relief, the German Weather Service, and the BBK. The project is intended to establish strategic cooperation for measuring and assessing climate change, and to prepare the public and emergency services for extreme weather events in the future. The goal is to coordinate risk management and disaster control projects in order to make the prevention, management, and response to natural disasters more effective.

Source
- Federal Office of Civil Protection and Disaster Assistance: http://www.bbk.bund.de/

Administrative Alliance: Adaptation of disaster control to climate change

In response to the heat wave of the summer 2003, the German Weather Service (DWD) established a country-wide heat warning system. It raises an alarm during periods of high temperatures, intense sunlight, and extreme humidity, which especially threaten older people. The warnings are transmitted to the health and social agencies of the respective states. In addition, the DWD has created a website and newsletter to provide information about heat waves. Some states have set up specific emergency plans, and have expanded existing education and information programs. The state of Hesse is regarded as a role model in this area. It has established a heat warning system that recommends behavioral as well as preventive guidelines for nursing homes and residences. The system also informs public health agencies, hospitals, and the public.

Sources
- Action plan for Public Health and the Environment: http://www.apug.de/
GREAT BRITAIN: PROJECT CASE STUDIES

London: A city prepares for climate change

Climate change presents numerous challenges for the British capital. Because of dense development, rising temperatures typically have large impacts in cities (the “urban heat island effect”). Rising temperatures also typically lead to a greater demand for water when available water resources are already low. Furthermore, high building density along the coast increases the risk of flood damages. The financial center of London also faces a challenge, because insurance companies based in London have invested more than their competitors in businesses with weather-related risks, making them particularly vulnerable to extreme weather events.

In 2007, the London Climate Change Partnership (LCCP) was established in order to prepare the city for these challenges. The LCCP is a working group of stakeholders from 30 organizations representing different sectors, coordinated by the Greater London Authority. The mission of the LCCP is threefold: to integrate adaptation to climate change into the political and administrative process of Greater London; to adapt London’s urban landscape to changing conditions; and to inform and educate citizens about the risks and opportunities of climate change. Project case studies of the LCCP include the development of a climate-resilient public transport concept, and the design of an economic model that facilitates a better understanding of the incentives needed to induce consumers to invest in products and services relevant for adaptation.

In addition, Boris Johnson, the new mayor of London, initiated the development of a London Climate Change Adaptation Strategy, to be unveiled in 2009. The priorities of the strategy include resident education about the impacts of climate change, the expansion of green spaces, and improved water management and flood protection.

Source

Water Saving Group: Initiative for more efficient water use

Climate change will cause certain regions of Great Britain to experience by water scarcity. Some households in southern England already consume less water per capita than the inhabitants of most Mediterranean countries. The Water Saving Group (WSG), a working group established by the government in 2005, was tasked with determining a solution to the problem. The mission of the working group was to bundle the expertise and experience of all participants, to foster more efficient use of water by all citizens, and to significantly reduce per capita water consumption by British households. In order to reach this goal, a common database on water efficiency was created and incentives for more efficient water use were developed. Although the task force completed its work in November 2008, the participants continue their campaign to improve the management of water resources.

The WSG includes the Department for Environment, Food and Rural Affairs (DEFRA) and the Department for Municipal Affairs, the national water authority, and private water utilities.

Source
ASCCUE Project: Adaptation of urban spaces

The ASCCUE Project (Adaptation Strategies for Climate Change in the Urban Environment) aimed to further the understanding of the climate change consequences in urban areas. Based on this goal, they developed adaptation strategies for urban planning. The provincial coastal region of Lewes, Sussex, in southeast England, and the metropolitan region of Greater Manchester, in central England, were selected as model regions. These distinct communities illustrate the regional differences expected from the impacts of climate change in Great Britain, highlighting the differences between urban and rural areas, mainland and coastal regions, and central and south England.

The results of the project, which ran from 2003 to 2006, were:
- A catalogue for the assessment of climate risks and possible courses of action
- An evaluation of the consequences of global warming for building structures, urban green spaces, and for residents’ quality of life
- An assessment of the adaptation options for urban planning
- An analysis of the interdependency between adaptation to climate change and climate protection strategies

Source
- Center for Urban Regional Ecology (CURE), University of Manchester: http://www.sed.manchester.ac.uk/research/cure/research/asccue/

Thames Estuary: Long-term adaptation of flood protection

The Thames Estuary 2100 project is intended to protect the environs of the Thames estuary and the area around London from floods. It is a joint initiative of the bordering regional associations of the Environment Agency. The eight-year project is slated to end in 2010. The project’s mission is to estimate the needed level of flood protection during the next hundred years.

The following steps will be undertaken:
- Monitor the protection systems against waves in the area of the Thames estuary
- Inventory and project the life span of existing protection systems given the expected climate scenarios established in the project.
- Solicit support for the project from partners in politics, business, and society and foster cooperation among them
- Coordinate the different programs, studies, and consultation rounds and integrating the results into a long-term strategy

The goal is to develop a plan that outlines the needed flood protection systems for the Thames estuary, recommending where the systems must be built and when completed. The implementation plan should be designed to be flexible enough so that it can be adapted to more extreme climate models, for instance if sea levels rise faster than expected.

The Thames project also planned to accompany this process with a series of citizen consultations, to ensure that the planned preventive measures offer as much protection as possible without excessively interfering in the daily lives of affected citizens. The plan also hopes to minimize impacts on local ecosystems.

Sources
- UK Environmental Agency: http://www.environment-agency.gov.uk/te2100/
**Floating houses: Architecture of the future in especially threatened areas?**

Dutch architects and planners developed concepts for “amphibian houses” as a strategy for adapting to steadily rising sea levels. The planners’ idea is that houses need not be built on solid ground; they can also be built on water. The first project of this kind has been built close to the city of Maasbommel. Dura Vermeer, the largest building company in the Netherlands, built 46 houses that are anchored to the seabed and can move with the tides.

There are other concepts of water architecture to be explored, such as houses on stilts and waterproof houses. Like the “amphibian houses,” these would be connected to the power grid and water supply. Especially since the 2005 Request for Proposals from the Ministry of Housing, Spatial Planning and the Environment (VROM), interest in floating houses and cities as a way to adapt to the impacts of climate change has greatly increased.

Such houses are also being tested in other cities, such as London and Hamburg. The two cities have built an alliance with the Dutch city of Dordrecht within the framework of the Urban Flood Management (UFM) project, which is co-financed by the national Living with Water Program. A key concern of the three cities is to transfer knowledge about risk assessments and management.

**Sources**
- Dutch water architects: [http://www.waterstudio.nl/](http://www.waterstudio.nl/)

**Innovative coastal protection**

The entire North Sea region increasingly accepts that floods caused by climate change cannot be prevented entirely. Therefore, the focus is shifting to the development of robust dike systems that do not collapse in case of extreme flooding. In several locations in Northern Holland the government decided has built stable, "overflow-able" dikes. In case of extreme floods that overflow the main dike, they permit controlled flooding into dedicated overflow areas. Following the storm floods, an integrated pump directs water back into the sea. The planned overflow relieves the main dike and facilitates long-term stability.

The European project exemplifies integrated planning by bringing together stakeholders with different perspectives (tourism, agriculture, environmental protection, and residents), thereby promoting acceptance of the dike system.

**Source**
- ComCoast: [http://www.comcoast.org/](http://www.comcoast.org/)

**Innovative coastal protection**

In order to improve flood protection, new sensor technology collects data on the conditions of, and pressures on, the dike systems. To achieve this goal, two Dutch research institutions (Deltares, TNO), one foundation (STOWA), and two companies (Stichting IDL, N.V.NOM) have launched the “smart dike” (IJkdijk) initiative. The mission of the initiative is to support companies in the northern Dutch province of Groningen with the development and spread of new sensor technologies.

The sensor technology serves as an early warning system for floods, identifying and reducing the risks associated with increasing drought or contamination. Experts also hope that a better geophysical understanding of dikes might also reduce
the number of unnecessary and expensive dike elevation projects.

**Source**
- Stichting IJkdijk: http://www.ijkdijk.nl/ng04/
“Climate change and hydropower”: hydropower needs planning reliability

About 60 percent of the electricity produced in Switzerland comes from hydropower plants. Thus, the possibility that hydropower will be adversely affected by climate change is a significant concern. In order to anticipate and prepare for the potential impact of climate changes, the hydropower industry has ordered an integrated projection of all relevant information, including availability of resources, vulnerability of power infrastructure, and future demand for electricity. According to energy experts, it is only in this way that the security of energy supplies can be guaranteed in Switzerland.

The purpose of the project Climate Change and Hydropower is to provide the basis for this integration. In September 2007, the final report of a preliminary study was published; the main study is to be completed in autumn 2010. The preliminary study offers a comprehensive overview of the relationship between climate change and the use of hydropower. The aim of the next phase of the project is to provide a framework for planning the use of hydropower in light of the expected changes in the water supply. The project aims finally to develop a robust model for estimating the risks and opportunities for hydropower with regard to climate change.

The project was initiated by the Swiss Mountain Water Network in cooperation with the hydrology group of the University of Bern, the Swiss Federal Institute of Technology, and the Federal Research Institute for Forests, Snow, and Landscape. The project was co-funded by the Federal Energy Agency.

Sources
- Preliminary study of project Climate Change and Hydropower: www.mountain-water-net.ch/FILES/pdf/Projekt_Klimaenderung_Wasserkraft_Vorstudie_Schlussbericht.pdf

Cartographic Representation of Permafrost in Switzerland (PERMOS)

Rising temperatures in Switzerland threaten the so-called permafrost floor, which covers 5 percent of the country. Permafrost is soil that is deeply frozen and has temperatures below 0°C all year long. Most common in the Alps above the tree line, permafrost is very sensitive to changes in climate. Permafrost that melts due to rising temperatures loses its stability and consequently is subject to increased risks from erosion and of avalanches, slumps, and landslides.

In order to better understand these risks, the Swiss Academy of Sciences (SANW) initiated the project Permafrost Monitoring Switzerland (PERMOS) in 2000. Project partners are the Federal Environmental Agency, several Swiss universities, the Federal Institute for Snow and Avalanche Research (SLF Davos), and other organizations. The project partners hope that a long-term network will allow PERMOS to systematically monitor and document the condition of the permafrost. Since 2003, the results of PERMOS have been published biannually, alternating with the report on changes in Swiss glaciers. The results were also incorporated in the Hydrologic Atlas of Switzerland (HADES). In 2007, a broad evaluation study confirmed that PERMOS provides important results on the processes of climate change. The project will also help develop further adaptation strategies.

Sources
Emerging Climate Change Adaptation Strategies Around the World

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Sources

The Mattmark Storage Lake Near Saas-Fee: Power production and flood protection

In 2001, together with the power provider Mattmark AG, the Swiss canton of Valais developed a flood protection program, building cooperation between the private energy utility and the government. While it addressed some building measures, the most important provision stipulated that the regional water utility provide a greater capacity for flood protection. While this measure adversely affected power generation, the resulting loss of performance in the Mattmark power plant was compensated by the canton. The agreement resulted in lower costs for the protection of municipalities at the lower reaches of the river, as compared to the expenses associated with riverbank engineering.

In 1969, the Mattmark Dam located close to Saas-Fee in the canton Valais started to produce energy. Despite the relatively small watershed area of 37.1 km² of the storage lake, the storage power station has been very important for flood protection in the region. This became apparent during the huge flood of 1993. Even though 92% of the storage lake was filled, it held back enough water to protect the town of Visp and its chemical plants, preventing an economic and ecologic disaster.

Sources
**Risk Maps as a Basis for Land Use Planning**

The development of risk maps is crucial to the process of preparing land use planning for the impacts of climate change. The maps reveal where housing is threatened by flooding, avalanches, rock falls, or slumps. The level of completion of these risk maps depends on the kind of risk and on the specific canton. In the beginning of 2006, 23% of risk maps were completed for slumps, 29% for rock falls, 30% for flooding, and 66% for avalanches. Overall, cantons located in the mountains are more advanced than lowland cantons. By 2011, comprehensive risk maps are to be available. The next step will be to develop more detailed maps. A federal law on land use planning requires that local land use projects and plans incorporate the likelihood of natural disasters identified in the integrated risk maps.

**Source**


**The Village of Pontresina Protects Itself from Avalanches and Melting Permafrost**

Pontresina, a small tourism center located in the Swiss Engadin, has a long history of being threatened by avalanches. The municipality considered the impacts of climate change and recognized the danger of avalanches and landslides caused by thawing permafrost early on. In order to mediate these risks, the community built the Giandains Dam in Val Giandains, located below an area of melting permafrost. The dam is more effective than traditional avalanche protection systems and blends into the natural scenery.

**Sources**


**Innovative coastal protection**

Irregular amounts of rainfall, increasing soil erosion, the melting of glaciers, and the thawing of permafrost all contribute to an increased risk of flooding. While preventive building measures are important, early warning is crucial to protecting against floods. Early warning can protect people, buildings, and infrastructure.

The creation of an early warning system is especially challenging, as the Rhine and its tributaries run through several countries with varying topographies and climates. The comprehensive cross-border Rhine Flood Early Warning System (FEWS Rhine) was developed in response to this complex challenge. It was developed by the Swiss Federal Office for Water and Geology (BWG) in cooperation with RIZA, the research institute of the Dutch water authority (Rijkswaterstaat). The extended system covers the whole watershed of the Rhine, from its headwaters to estuary.

The forecasts of the BWG are updated around the clock in critical flood areas, and the information is made available on the internet and via telephone and automatic fax, so that affected or interested parties can get updates free of charge. The Swiss forecasts are used for the warning systems of the communities located downstream, which helps prevent flooding catastrophes in the other Rhine riparian states such as Germany, France and the Netherlands.

**Sources**

SPAIN: PROJECT CASE STUDIES


Water scarcity due to long periods of drought represents a growing risk to the water supplies of many Spanish cities. For instance, in 2008, Barcelona’s drinking water supply was at risk because of a very dry winter. At the beginning of the summer, water levels were extremely low in the city’s most important storage lakes. An emergency plan was developed in response that stipulated that the city be supplied with water from tankers as well as by a pipeline from the Ebro river.

The Ministry for the Environment cooperated with the Association of Spanish Water Utilities (AEAS) to publish a handbook for cities with more than 20,000 inhabitants. The handbook provides guidelines for the development of emergency plans to address water scarcity and describes the most important steps when preparing for water shortages. These include:

- Assessing the water demand and the available resources
- Evaluating the risk of water scarcity
- Developing measures to reduce the risk of water scarcity
- Defining reduction targets for the use of water
- Organizing an emergency management program

The handbook includes a standardized system for estimating water resources and assessing the phases of water scarcity. This allows cities to better prepare for periods of drought and enables the coordination of these issues at the national level.

Source
- Guía para la elaboración de Planes de Emergencia por sequía en sistemas de abastecimiento urbano, AEAS / Ministerio de Medio Ambiente, 2007.

Reduction of water consumption in new building projects

During the last decade the Spanish Mediterranean coast experienced a construction boom, especially in its tourism industry. The overall environmental impact to the region was negative with the destruction of vulnerable coastal ecosystems and a significant increase in water demand by the new development.

In order to deal with the problem, the real estate company Bancaja Habitat built the settlement Urbanización Panorámica, Sant Jordi along the Mediterranean coast in Catalonia. Characterized by a very efficient use of water, the housing development is located in an area where strong rainfalls alternate with periods of drought.

A well provides the settlement with water. Additionally, a system that collects and uses rainwater was installed, which significantly reduces the need for ground water. Run off water from the settlement as well as from the nearby golf course is filtered through a special water treatment plant and stored separately. Furthermore, some of the used water from the settlement is filtered and reused afterwards. Thanks to the system, 40% of the settlement’s water consumption is met by reused water.

Sources
- Bancaja Habitat: http://www.bancajahabitat.es/
Ibero-American Network of Climate Change Offices

Besides national and local activities, international exchange initiatives represent another important avenue for developing climate change adaptation strategies. The Ibero-American Network of Climate Change Offices (Red Iberoamericana de Oficinas de Cambio Climático– RIOCC) represents a good example of international cooperation and political coordination on climate change.

In October 2004 the Network was established by the environmental ministers of several Latin-American countries as well as Spain. Since then, the Spanish Agency for International Development Cooperation (AECID) has acted as a moderator and supporter of the Network for the 21 countries that participate. The Spanish Climate Change Office is a member of the Network and provides expertise for the initiative. The goal is to prepare and coordinate climate change policy between the countries of Latin America and Spain.

The summits of the member states take place on a senior political level. Most of the time, the countries are represented by their respective environmental ministers and the results are presented at the Latin-American presidential summits.

Adaptation to the impacts of climate change is one of the most important priorities within the RIOCC. In 2005, the members agreed on the Ibero-American Program for Climate Impact Evaluations, Risk Assessments and Adaptation Strategies (Programa Iberoamericano de Evaluación de Impactos, Vulnerabilidad y Adaptación al Cambio Climático–PIACC). The program aims to develop and implement respective strategies in the region. It fosters the coordination of activities as well the exchange of information and experience. Action areas include:

- Promoting regional initiatives and institutions
- Supporting research and climate monitoring
- Generating and collecting relevant data on climate change and its impacts in Latin America as well as on adaptation options
- Exchanging experiences and methods for risk assessments and adaptation to the consequences of climate change
- Supporting international, participatory and cross-sectoral projects

Source
Toronto: Pioneer in handling heat waves

Larger cities are more affected by increasing temperatures than their surrounding areas. Dense construction creates the so-called “urban heat island.” This also applies to Toronto, where average temperatures inside the city can be up to 3°C higher than the surrounding area.

In response to the extreme heat wave of the summer of 1999 that caused 120 casualties, Toronto has launched a series of initiatives to fight the impacts of heat waves. This makes Toronto a role model for climate change adaptation.

One groundbreaking project in Toronto is its heat emergency plan. Preventative measures have been developed that target groups who are especially vulnerable to health risks during a heat wave. Risk groups include senior citizens who live alone, individuals with chronic diseases, small children, low income households, and homeless people.

Based on local weather and medical data, health authorities have developed an alarm system with two levels of warnings. In a Level One heat warning, the health authorities activate a special emergency hotline, distribute free water bottles, inform the media, and notify organizations serving vulnerable groups such as child care centers, nursing homes, and hospitals. In a Level Two heat warning, more extensive measures are taken. For instance, air-conditioned public buildings are opened as a shelter, and free public transportation is provided for risk groups to reach these facilities. Despite such efforts, a significant number of people died during the summer of 2005. Therefore, the program is systematically being improved and expanded.

Another initiative, the Cool Toronto Program, is aimed at urban planning solutions to mitigate heat. The program includes expanding green spaces, planting shade trees, fostering air circulation with ventilation corridors, and promoting green rooftops.

In addition, the city also aims to foster the use of lighter colored materials in buildings and infrastructure (such as lighter paving or roof tiles); these materials reflect the sun’s light instead of absorbing it.

Sources
- Urban reforestation in Toronto, Canada. UNFCCC, Database on local coping strategies: http://maindb.unfccc.int/public/adaptation/adaptation_casestudy.pl?id_project=149
- City of Toronto: http://wx.toronto.ca/inter/it/newsrel.nsf/0/068b796a88bb09c685256df600461170?OpenDocument
- City of Toronto: http://www.toronto.ca/health/heatalerts/index.htm

Climate SMART: An integrated climate strategy on the municipal level

In past years, the city of Halifax suffered from various extreme weather events including hurricanes and blizzards. The capitol and largest city of Nova Scotia, Halifax is no stranger to ocean storms and has seen people die and millions of dollars in damages.

In order to manage the increased risks associated with climate change, and especially to be better prepared for extreme weather events, the city sought to create a system that would allow them to systematically develop and implement adaptation planning and climate protection measures. In 2004, the city launched Climate SMART (Sustainable Mitigation and Adaptation Risk Toolkit). Climate SMART integrates both climate protection and adaptation into the local planning and decision-making processes.

The systems supports:
- Risk and sustainability analyses
Climate SMART is a public-private partnership. The city participates in the pilot project, along with the Federation of Canadian Municipalities, the Canadian Ministry of Natural Resources, the Canadian Ministry for the Environment, the Ministry of Energy of Nova Scotia, the Ministry for Labor and the Environment of Nova Scotia, the Association of Environmental Companies in Nova Scotia, and several citizens’ initiatives and local companies.

Sources

Water For Life: A water strategy for the province of Alberta

Dramatic population rise, along with growth in agriculture and industry, have substantially increased the demand for water in the central Canadian province of Alberta in the recent past. The increasing frequency of extreme droughts during the summer season as a result of climate change will likely lead to a volatile and unpredictable water supply.

In order to tackle this challenge, the provincial government has developed a water strategy (Water for Life: Alberta’s Strategy for Sustainability). The goal of Water for Life is to raise awareness among the public and business community about Alberta’s water scarcity and to motivate people to use water more efficiently. The strategy aims to increase water efficiency by 30% by 2014, to ensure a sustainable water supply for the future.

The public has been actively involved in the process. Besides formulating basic goals and principles, the initiative established the Alberta Water Council and local advisory groups that formulate recommendations for improving water management. Monitoring systems were improved and water information centers created.

Sources
- Water for Life: http://www.waterforlife.gov.ab.ca/
- Natural Resources Canada: http://www.nrcan-rncan.gc.ca/sd-dd/pubs/h2o/3-2_e.html#f26

Integrated Forest Management in the Yukon Territory

Climate change brings serious changes for the Yukon territory on Alaska’s border. Due to rising winter and summer temperatures, the Yukon has already experienced a bark beetle infestation on a scale never before seen. The consequences are changes in the ecological balance, impacts on flora and fauna, and an increased risk of forest fires caused by the increased amount of dead and dry wood.

The livelihood of the people is threatened, especially for those who work in the regional forestry and timber industries. In reaction to this challenge, the provincial government has cooperated with the local population to develop a comprehensive forestry management plan. The aims are to reduce the risk of forest fires, to foster reforestation, to protect the flora and fauna, and to support the local economy. Various workshops and research initiatives have been launched to support
the development of the plan. The traditional knowledge of the Native American tribes is also incorporated into the process.

Sources

A land use model for the loss of permafrost in Salluit

The melting of the permafrost in the Arctic caused by rising temperatures is not the only consequence of climate change. As the permafrost thaws, it releases methane that has been frozen in the ground, which further accelerates the process of global warming. The melting of permafrost also affects local ecosystems and the livelihood of local populations. One example is the Inuit settlement of Salluit in the region of Nunavik, located in the far north of the province of Quebec.

As the temperature of the permafrost rises, ground and surface water conditions are affected, directly affecting the local topography and vegetation. The stability of the ground decreases and land subsidence can occur more frequently. As the ground literally shifts, buildings and infrastructure can be damaged. In addition, many transport routes built on permafrost grounds can no longer be used, a major obstacle to the local economy. Salluit is also threatened by coastal erosion.

To tackle these problems, the Quebec-based research institutes Center for Nordic Studies (Centre d’études Nordiques) and Ouranos have developed a geologic and geothermal model for Salluit that will map and assess all factors of ground stability. The goal is to develop a map based on this model that identifies the most endangered areas and shows options for future land use. In addition, new technologies that slow down the warming of the ground, such as reflecting surfaces and heat drains, are being tested in Salluit.

Sources
- Centre d’études nordiques (CEN): http://www.cen.ulaval.ca/english/pergelisol.html
- Natural Resources Canada: http://ess.nrcan.gc.ca/2002_2006/rcvcc/j32/5_e.php

The Confederation Bridge

The climate changes on the Canadian Atlantic coast were incorporated into the construction plans for the Confederation Bridge in the 1990s. The Bridge traverses the Gulf of Saint Lawrence in Eastern Canada, and links Prince Edward Island with the North American mainland in New Brunswick. The bridge was completed in 1997 and at 12.9 kilometers is the longest bridge in Canada.

One of the greatest challenges to the installation is the big pieces of ice that drift under the bridge during the winter and spring. Climate scenarios helped to determine the required distance between the bridge piers in order to ensure sufficient space for the ice to flow through. To prepare for rising sea level, the headway for passing ships is also greater than that of comparable bridges elsewhere.

Sources
- OECD, “Progress on Adaptation to Climate Change in developed Countries”: http://www.oecd.org/dataoecd/49/18/37178873.pdf
United States: Project Case Studies

Water Utilities Climate Alliance

In 2008 eight US water utilities joined forces in a climate alliance: Seattle Public Utilities; Denver Water; Metropolitan Water District of Southern California; Portland Water Bureau; San Diego County Water Authority; San Francisco Public Utilities Commission; New York City Department of Environmental Protection; and the Southern Nevada Water Authority. The alliance aims to advance research in the field of water management and water supply, and to use the results for the development of adaptation strategies. Seattle Public Utilities (SPU) has been an early pioneer in this regard. SPU cooperates with research institutions and incorporates scientific climate projections into its water and risk management. The company develops annual forecasts for water supply and water demand. It also identifies low- or zero-cost measures available for adaptation to climate change.

Sources

PLANYC 2030: New York City prepares for climate change

In April 2007, Mayor Bloomberg released PlaNYC 2030, a comprehensive environmental action plan for New York City. A section of the report highlights the impacts of climate change on New York City resources, and outlines three specific goals for addressing adaptation: the creation of an intergovernmental task force to protect infrastructure; the development of site-specific strategies for neighborhoods; and the launch of a citywide strategic planning process for climate change adaptation.

The NYC Department of Environmental Protection (NYCDEP), responsible for managing the city’s water supply, sewer, and wastewater treatment systems, also established a task force to develop responses to climate change. In May 2008, the NYCDEP released an updated climate action report with a section outlining their next steps in adaptation planning. This report is the first step to include adaptation concerns in long-term strategic and capital planning, including updating New York’s 100-year floodplain maps, amending the building codes (relevant to water management), and documenting the city’s floodplain management strategies.

Sources

King County, Washington: Local preparations for global warming

King County, with its county seat of Seattle, is widely recognized as a national leader in adaptation planning. The county’s adaptation plan is part of a comprehensive climate action plan, and contains strategies for both mitigation and adaptation. The plan does not delve into specific actions on adaptation, but directs that the relevant county departments devise implementation strategies and goals. To date, departmental planning is ongoing. Another part of the county’s adaptation plan is to fund climate studies to refine the county’s understanding of local impacts in order to guide adaptation efforts. As discussed above, King County has also worked with ICLEI to draft a guideline for local governments in the US on adaptation planning.

The county is also examining its current programming to determine what might need to be expanded as the climate changes. One such program is the King County Flood Buyout and Home Elevation Program. This program will purchase homes
in areas prone to floods or serious erosion; both flood and erosion are expected to increase under climate change. The program also assists homeowners with the costs of raising the finished floor of the home above the 100-year flood level.

Sources
- King County. (2007). 2007 Climate Plan. Seattle, WA.

Heat Wave Plan for Philadelphia

The city of Philadelphia first published a heat wave plan in 1993, which included a range of concrete measures to cope with the rising number of extreme heat waves anticipated in the future. The plan included a warning system for at-risk populations that are particularly affected by climate change (e.g., single elderly people, the homeless). The plan also established neighborhood support networks and plans to use public buildings as air-conditioned emergency shelters. The data required for the plan were provided by the Heat Health Watch-Warning System. Energy and water utilities pledged to supply customers during heat waves, even those whose accounts were overdue. Between 2001 and 2003, the city’s Energy Coordinating Agency (ECA) also implemented the Cool Homes Program, which initiated various projects and education campaigns for disadvantaged social groups. For instance, in the project Cool Blocks, ECA gave participants free advice on cooling their homes and saving energy; ECA also insulated roofs and windows. Studies have since demonstrated that the plan reduced health risks for the residents.

Source

Deer Island Wastewater Treatment Plant: Preventive building measures

During the 1990s, the Massachusetts Water Resources Authority decided to build their new wastewater treatment plant on more elevated ground due to concerns over sea-level rise. The plant is located on an island in Boston Harbor; the decision to use elevated ground was made to avoid the long-term costs of building a dam around the facility in the event of an expected rise in sea-level. The measure is regarded as one very early example of climate-resilient infrastructure planning in the US.

Meanwhile, the city of Boston has a comprehensive plan to deal with the consequences of climate change. The mayor initiated the development of an integrated adaptation plan to reduce climate-related risks for the city and to coordinate the different authorities involved for the implementation of adaptation measures. For instance, the city requires future climate risks to be considered in every proposed public building project, whether it be new construction or major renovation.

Sources
- Massachusetts Water Resources Authority: http://www.mwra.state.ma.us/index.html
- Menino, T.M. (2007), An Executive Order Relative to Climate Action in Boston, Boston, MA: City of Boston, Office of the Mayor.
Entergy Corporation: Business continuity planning

The Entergy Corporation, an energy utility headquartered in New Orleans, Louisiana, is one of the most important regional energy suppliers. In 2005, Hurricanes Katrina and Rita hit the Entergy Corporation as hard as they hit the whole region. The estimated damage to the company was US $2 billion, which demonstrated the company’s vulnerability to climate risks. The extremely hot and dry summer of 2000, followed by that winter’s strong snow storms, had already illustrated this fact. In response, the company implemented a variety of measures intended to reduce the potential damage that global warming might inflict on the company’s infrastructure and distribution channels.

Although Entergy kept its headquarters in New Orleans, portions of its critical infrastructure have been transferred to other, less risky regions. A Business Continuity Group (BCG) has been established to analyze the risks of climate change and other potential dangers. The BCG developed a model for evaluating short-term (20 years), medium-term (20 to 50 years) and long-term (until 2100) climate risks, as well as the related risk scenarios for the company. Thanks to these scenarios, company units that are particularly at risk can be identified. At the end of the process, detailed action plans will be available.

Source

Florida: Climate change adaptation

In July 2007, Governor Charlie Crist issued Executive Order 07-128, establishing the Governor’s Action Team on Energy and Climate Change and charging it to create a state Climate Action Plan. The Team’s Phase 1 report, published in November 2007, did not address adaptation. The Team’s Adaptation Technical Working Group developed recommendations for “adaptation strategies to combat adverse impacts to society, public health, the economy, and natural communities in Florida”; these strategies were published in a Phase 2 report in October 2008. The Working Group has already developed a catalog of potential recommendations focused on building codes, natural resources management, emergency preparedness, etc., based in part on an adaptation report developed by Florida Atlantic University.

Sources
Oregon: Climate change adaptation

Oregon: In 2006, Governor Ted Kulongoski created the Climate Change Integration Group, which was charged with building on the work of the 2004 report from the Governor’s Advisory Group on Global Warming. The Integration Group’s primary focus is on adaptation in the face of rapid climate change, and the final report was published in 2008. Like the other states discussed in this document, the Oregon report contains recommendations for the development of adaptation plans. To date, these recommendations have not been codified into formal government policy.

Sources

Washington: Climate change adaptation

Governor Christine Gregoire created the Washington Climate Challenge, and tasked the Departments of Ecology and of Community, Trade and Economic Development with developing a climate action plan. As part of the planning process, the Departments convened Preparation and Adaptation Work Groups (PAWG) to focus specifically on adaptation recommendations. The PAWG prepared a draft set of recommendations focusing on human health, agriculture, infrastructure, forestry, water resources, and fish and wildlife resources.

Sources

Climate Change Adaptation in Keene

The city of Keene, in the northeastern state of New Hampshire, has developed a comprehensive adaptation plan through the ICLEI Climate Resilient Communities initiative. Keene, which has a population of less than 25,000, was the first city to join ICLEI’s adaptation program. In developing adaptation plans and priorities, a committee made up of local government officials and staff, community members, and scientists, prioritized Keene’s impacts and vulnerabilities. The cumulative results identified the top five climate vulnerabilities within each of three sectors: the built environment, the natural environment, and social environment. The committee then identified measurable targets to achieve each adaptation goal. One of the major recommendations in the report is to incorporate relevant portions of this plan into the city’s comprehensive master planning process. The plan also recommends that the city redirect energy savings into a fund to hire a full-time Sustainability Coordinator for the city.

Sources
Climate Change Adaptation in Boston

In April 2007, Mayor Thomas Menino issued an executive order that contained adaptation provisions. The order required city government to prepare an integrated adaptation plan to reduce risks from likely climate impacts, and to coordinate adaptation implementation among departments. Furthermore, all new construction and all major renovations of municipal facilities must evaluate the risks posed by climate change. The city is in the process of putting these directives into effect.

In 2004, the regional planning organization for the Boston metropolitan area released the Climate’s Long-term Impacts on Metro Boston (CLIMB) report, a comprehensive research project to assess how infrastructure is affected by climate change. The CLIMB team aimed to provide plausible cost estimates of climate impacts on Boston area infrastructure systems. However, the report has not yet informed local action.

Although Boston is still in the planning stages, there is one example of adaptation infrastructure planning in the city. The Massachusetts Water Resource Authority (MWRA) built the Deer Island wastewater treatment plant to process sewage for the Boston region. In anticipation of sea-level rise, the MWRA built the Deer Island plant about half a meter higher than originally planned. The design engineers were concerned that without this change in height, sea-level rise would necessitate construction of a wall and would reduce water pressure in the system. However, this approach to building has not become standard practice in the city.

Sources


Florida: Climate change adaptation

In terms of the assets exposed in a 100-year flood, Miami-Dade (Florida) is one of the most vulnerable regions in the US. Predicted economic losses are estimated at roughly $416 billion. With this in mind, in July 2006, Miami-Dade County established an advisory taskforce on climate change and impacts, and joined the ICLEI CRC program. In April 2008, the advisory task force released climate change impacts and recommendations for adaptation policies. The report divides adaptation categories into natural systems, property and infrastructure, intergovernmental affairs, and economic, social, and health adaptation. Recommendations for adaptation policies include purchasing and restoring wetlands throughout the region as buffer zones for climate impacts, and emphasizing the importance of the Everglades restoration project. The report also highlights the need to engage other local and state governments for better regional planning in the built environment; an example would be to require all government agencies to assess the impact of sea-level rise.

Source

Climate Change Adaptation in Homer, Alaska

In January 2007, the mayor of this small Alaskan town established a task force on climate change. By December of 2007, the task force released its climate report, with a significant section on recommendations for adaptation measures. Evaluating likely sea-level rise, storm surges, and coastal erosion, the report recommends taking “proactive measures to protect or relocate at-risk infrastructure.” Emergency preparedness, and future infrastructure and development projects, will be planned to reduce the impacts from climate change.

Source
- City of Homer. (2007). City of Homer Climate Action Plan: Reducing the threat of global climate change through government and community efforts. Homer, AK
Adapting the Great Barrier Reef to a Changing Climate

The Great Barrier Reef stretches over 2,300 kilometers along the northeastern coast of Australia, and is considered to be the greatest and most spectacular reef in the world. The reef has unique flora and fauna, and was selected a World Heritage site by UNESCO in 1981. It is also of great economic importance for Australia’s tourism and leisure industry. According to the Great Barrier Reef Marine Park Authority (GBRMPA), the tourism and leisure industry connected to the reef contribute 6.9 billion Australian dollars to the economy.

The 2007 IPCC report shows that the Great Barrier Reef will be one of the habitats most affected by climate change. Rising sea level and increased temperatures threaten corals, causing them to bleach out and die due to the resulting aquatic acidification. It is expected that these impacts will significantly affect biodiversity, fisheries, and tourism in the region. Extensive adaptation measures are needed to protect this unique nature reserve.

Therefore, the GBRMPA developed an action plan (Climate Change Action Plan 2007–2012), included adaptation strategies for the reef. It is based on a comprehensive assessment of possible impacts of climate change on the Great Barrier Reef (Climate Change and the Great Barrier Reef: A Vulnerability Assessment). It focuses on four main goals: further improvement of the impacts of climate change on the Great Barrier Reef; improvement of the resilience of the ecosystem; adaptation of the businesses and local communities; and reduction of the carbon footprint.

Sources
- Great Barrier Reef Foundation: http://www.barrierreef.org/

Adaptation to Climate Change as a Field of Study: Master of Climate Change Adaptation

In May 2008, Penny Wong, the Australian Minister for Climate Change and Water, announced a capacity building program for the adaptation to climate change. The program is dedicated to training of local governments and experts (such engineers and architects) to develop a better understanding of how to manage the impacts of climate change.

One example is the Engineering Sustainable Solutions Program, which is run by the think tank The Natural Edge Project. The goal is to educate professionals and students in the water management sector about climate change impacts. The project focuses on the likely impacts of changes in water availability and of sea level rise. The project will develop educational materials, which will be distributed online free of charge. The materials will include information about how the impacts of climate change have to be considered in planning infrastructure and buildings, and about technologies that are available for climate change adaptation.

Another example is the education program at the University of the Sunshine Coast in Queensland. The university offers a Masters Degree in Climate Change Adaptation. The program includes courses on the causes and dynamics of climate change, as well as on methods of sustainable resource management given the changing climate.

Sources
- University of the Sunshine Coast: http://www.usc.edu.au/Students/Handbook/Postgrad/SC702/SC702.htm#overview
The Natural Edge Project: http://www.naturaledgeproject.net/Sustainable_Water_Solutions_Portfolio.aspx

Australisches Ministerium für Klimawandel und Wasserversorgung:

South East Councils Climate Change Alliance

The South East Councils Climate Change Alliance (SECCA - formerly the Western Port Greenhouse Alliance) is a regional partnership founded in July 2004 to establish a regional framework for stakeholders. The framework is intended as a response to the challenge of climate change for the region; it includes both climate change mitigation and adaptation measures.

One of the current projects of SECCA is to assess the potential impacts of climate change on the region of Western Port and to identify possible adaptation options. The project also aims to raise awareness of the causes and consequences of climate change in the region. The project report will be the foundation for a stakeholder dialogue on the preparation for climate change.

Source

South East Councils Climate Change Alliance: http://www.wpga.org.au/
Adaptation Plan of the City of Durban

The city of Durban, located on the Indian Ocean, has more than three million inhabitants and represents the center of the South African province KwaZulu Natal. Due to its coastal location, the city is frequently affected by floods and storms, with significant impacts on the city’s infrastructure.

Climate change will likely increase these risks. As a result, the regional administration has been considering the possible impacts of climate change on Durban. In 2004, the Department for the Environment of the City initiated an analysis of the likely regional impacts of climate change. The increasing frequency of floods and droughts, the intensification of coastal erosion, damage to infrastructure, the decrease of water availability, and food insecurity were identified as important challenges. The analysis was extended through a discussion process with the relevant stakeholders in 2006, and then summarized in a report.

Based on this report, Durban developed the Headline Adaptation Strategy. The strategy identifies sectors that will be affected by climate change and develops guidelines for adaptation. In order to specify these guidelines and to integrate adaptation into the strategies and plans of the relevant sectors, the city is developing sector-specific plans (Municipal Action Plans). Important focus areas are water and health.

Sources
- id21: http://www.id21.org/insights/insights71/art05.html

Management of Climate Risks in the Western Cape Region of South Africa

The Western Cape is of great importance for South Africa. Due to its Mediterranean climate and its rich biodiversity, it attracts many tourists and is also an important region for the cultivation of wine and fruits. Water demand for agriculture and an increasingly urban population has increased in recent years. At the same time, the region is particularly affected by extreme weather events. A drier and warmer climate with changing precipitation patterns will cause water scarcity and droughts, and will increase the risk of bush fires. According to a study by the University of the Free State, agricultural production declined by 30 percent during the drought of 2004/2005. Water demand is expected to rise by 45 percent by the year 2020, and it is unclear where 20 percent of that increase will come from.

The provincial government is very active in the field of adaptation. In 2005, it published an evaluation of the impacts of climate change in the region. Additionally, the provincial government, along with the city government of Cape Town, launched numerous initiatives, workshops, and research programs. In 2007, a study was presented that discusses an umbrella organization for municipal adaptation plans. In the same year, the province published the draft of an adaptation strategy with an action plan, defining priorities and concrete guidelines for action.

Sources
- Study of the University of the Free State written within the framework of the program “Climate Change Adaptation in Africa”: http://www.idrc.ca/ccaa/
- Status Quo, Vulnerability and Adaptation Assessment of the Physical and Socio-Economic Effects of Climate Change
Protecting the Biodiversity of the Cape Peninsula

The Cape Peninsula, on the Atlantic Ocean in the far southwest of Africa, is famous for its impressive biodiversity. The unique ecosystem is not only threatened by the growth of the city of Cape Town, but also by the impacts of climate change. The peninsula’s status as a nature reserve, therefore, is no longer sufficient to protect its biodiversity.

The goal of *The Cape Peninsula Biodiversity Conservation Project* is to establish a national park. The focus of the initiative is on restricting the spread of invasive non-native species whose spread is linked to climate change, and to develop an action plan for emergency relief in the case of forest fires and coastal pollution. Furthermore, a process for the strategic planning for plant protection was initiated on the Cape Peninsula. Between 1998 and 2005, the project was managed by the National Parks Board and the Table Mountain Trust Fund. The World Bank provided funding.

Source
- Cape Peninsula Biodiversity Conservation Project:
  - www.ffem.net/jahia/webdav/site/ffem/users/admiffem/public/Plaquettes_projet/Biodiversity_peninsuleCap_eng.pdf

Tea Cultivation in the Northern Cape Region of Suid Bokkeveld

The NGO SouthSouthNorth initiated a project that aims to support local farmers of the South African region of Suid Bokkeveld by providing cultivation techniques adapted to the impacts of climate change.

In cooperation with the local population, the NGO is exploring the possibility of switching from the cultivation of conventional Rooibos tea to the cultivation of drought-resistant wild Rooibos tea. The idea stems from observations during the drought periods that Suid Bokkeveld experienced between 2003 and 2005. Four times per year, Climate Preparedness Workshops are held in order to exchange information and experience. The midterm goal of the project is achieve a foresighted adaptation plan for climate change and sustainable resource management.

Source
- SouthSouthNorth-Project Portfolio:
  - http://www.southsouthnorth.org/default.asp?/investorportal_home.asp?country_id=11
TANZANIA: PROJECT CASE STUDIES

Food Security Through the Cultivation of Drought-Resistant Plants

Climate change scenarios project an increased risk of continuous and prolonged droughts in some regions of Tanzania. This is particularly true for the regions of Shinyanga, Dodoma, and Singida. To tackle the impacts of climate change, and to improve the food security for the population, a NAPA project aims to support farmers in these regions with climate change adaptation. For example, the cultivation of corn, which is very vulnerable to droughts, will be reduced, while the cultivation of drought-resistant millet will be fostered. The measures include the identification of resilient crops, the distribution of seeds, and the training of farmers. The project is managed by the Ministry for Agriculture and Food Security in cooperation with local institutions, the national weather service and several NGOs, and has a budget of 8.5 million dollars.

Source
- United Republic of Tanzania, National Adaptation Programme of Action (NAPA), Division of Environment

Kilimanjaro Region: reforestation and raising public awareness

The snow-covered peak of Kilimanjaro is the highest point in Africa and is a landmark of Tanzania. However, the famous mountain is seriously affected by the consequences of climate change. The glacier atop Kilimanjaro is melting rapidly, and will probably vanish completely at some point between 2015 and 2020. Less visible is the threat to the entire Kilimanjaro ecosystem posed by changes in water balance. Historically, the region at the foot of the mountain has been densely wooded, providing habitat and wood resources for local populations. Melting glacial water, on which the local population depends, combines to form several rivers that feed the great Pangani river basin.

During the past years, unpredictable precipitation patterns, water scarcity and population growth have changed land use in the region. The local population has had to adapt to the changes, often by clearing forest in order to create new arable land. However, the loss of forests aggravates the cycle of water scarcity and soil erosion, further destabilizing the ecosystem.

In order to stop this cycle, the Ministry of Tourism and National Resources has cooperated with the Ministry of Energy and Minerals, research institutions, and NGOs to develop a joint project with a budget of 3.3 million dollars. The project aims to start reforestation programs and to find alternative sources of income for local populations. Overall, the purpose is to raise awareness of the importance of biodiversity and sustainability.

Source
- United Republic of Tanzania, National Adaptation Programme of Action (NAPA), Division of Environment, January 2007

Water Supply at Risk: Wells in coastal regions and on Zanzibar

The current rise in sea level has already had significant impacts on some coastal areas of Tanzania. Wells and other sources of drinking water in have been flooded, leading to contamination by salt water. The district of Bagamoyo, not far from Dar-es-Salaam, is particularly affected.

Within the framework of the NAPA project, alternative water sources are identified and new wells are built in Bagamoyo and other coastal regions. The project is directed by the Ministry of Water and Irrigation and other ministries, as well as local institutions and NGOs. The project also provides information about contaminated wells, assesses water quality, fortifies existing wells, and guides the population on adopting sustainable water use methods.
Emerging Climate Change Adaptation Strategies Around the World

Mini-Hydro-Electrification

The north Tanzanian village of Luguru, located close to the border to Kenya, has been evaluated as a case study to improve the understanding of the impacts of climate change for the municipal economy, and to develop appropriate adaptation strategies. Traditionally, wood has been the main resource and energy source of the community. New climatic conditions have reduced the fertility of the soil. As a consequence, the forest was clear-cut to create new arable land, which led to a shortage of wood as an energy source.

A NAPA project with a budget of 620,000 dollars, initiated by the Ministry of Energy and Minerals in cooperation with other national and local institutions as well as NGOs, plans to install a “Mini-Hydro” generator in a nearby river. The hydropower station uses simple technology. In order to ensure the long-term success of the project, the local population is trained to manage the small hydro plant independently.

Fighting malaria in regions newly infested with mosquitoes

As a consequence of climate change, malaria, a tropical disease that is often lethal, is spread to regions in Tanzania where it did not occur in the past. This is the case for the regions of Kilimanjaro, Arusha, Tanga, and Kagera.

As a result, a NAPA project was launched by the Ministry of Health and Social Welfare in cooperation with the office of the Prime Minister, other ministries, the media, and NGOs. The project intends to raise awareness of the risks of malaria and the symptoms of the disease in newly infested regions. Furthermore, local doctors and hospitals are provided with guidelines on malaria. Another approach is to foster the use of traditional medicinal plants. The budget of the project is about 650,000 dollars.

Source
- United Republic of Tanzania, National Adaptation Programme of Action (NAPA), Division of Environment
BANGLADESH: PROJECT CASE STUDIES

Protecting Housing in the Chars against Flooding

Chars, or small islands and hooks in river deltas, are particularly affected by flooding. Despite the risky living conditions, due to the country’s high population growth and the limited land availability, many Bangladeshis settle in these areas.

The British Department for International Development (DFID) funded the Chars Livelihood Programmes. The programs are intended to build flood-protected houses on the Chars of the Jamuna river, the main arm of the Brahmaputra in Bangladesh. The goal is to elevate 100,000 houses by about 60 cm, the level of the large floods of 2004. So far, 30,000 houses have been elevated. Other measures include the construction of latrines and the expansion of the supply of drinking water.

Along with building and adaptation measures, the project also incorporates social aspects. The economic activities of the Chars’ inhabitants are supported, for instance, through leasing land and improved cattle breeding.

Source
- Chars Livelihoods Programme: http://www.clp-bangladesh.org/

Cultivation in floating gardens

Bangladesh has the highest rate of wetlands worldwide. As a result, traditional cultivation methods must be modified. The cultivation of crops on floats (soil-less agriculture or hydroponics) represents a possible alternative to conventional cultivation approaches. This method has attracted much interest especially because of the increasing risk of floods. This cultivation method is not only highly productive, but it also uses local, easily accessible agricultural inputs, such as water hyacinth.

The floats consist of two layers. Normally, the lower layer consists of water hyacinths, while the upper layer is made of plants that decay rapidly and serve as fertilizer. The method is mainly used for the cultivation of okra, curcuma (i.e., ginger and turmeric), cucumbers, tomatoes, and potatoes. The floats can be used for two to three seasons. Afterwards they can serve as fertilizer.

Within the framework of the SHOUHARDO-Program (Strengthening Household Abilities for Responding to Development Opportunities) the NGO CARE Bangladesh implemented several pilot projects in three municipalities, with funding from the US development agency USAID.

Sources
- Hydroponics in Bangladesh. UNFCCC, database of local coping strategies http://maindb.unfccc.int/public/adaptation/adaptation_casestudy.pl?id_project=8
- IUCN: http://www.iucnbd.org/projects/baira.html

Protecting Houses against Floods through Microcredit and Microlending

The Grameen Bank has become famous for its microcredit program. In 2006, the founder, Muhammad Yunus, was awarded the Nobel Peace Prize for his pioneering work in the field of microfinance. These small loans are paid back on a weekly basis. The microcredit system builds on a system of shared responsibility: Families and communities support each other, thereby realizing a payback rate of close to 100 percent.

The Grameen Bank plays an important role for the adaptation to the impacts of climate change. Since 1984, the bank has
given out credits for the building of houses, and supports the population by funding preventive measures against flooding. The approach has become very important for the adaptation strategy in Bangladesh. To date, 600,000 houses have been funded with credits of the Grameen Bank.

Sources
- Flood-resistant housing through micro-loans in Bangladesh. UNFCCC, database of local coping strategies: http://maindb.unfccc.int/public/adaptation/adaptation_casestudy.pl?id_project=38
- Mainstreaming and Financing of Adaptation to Climate Change, Ancha Srinivasan and Toshihiro Uchida
## BASIC-Project

The BASIC-Project (Building and Strengthening Institutional Capacities on Climate Change in Brazil, India, China and South Africa) is a practice-oriented research project aiming to strengthen the institutional structures with regard to climate adaptation in four important transition countries. Each of the four participating countries is focused on particular aspects. The Indian team, which consisted of different research institutions, think-tanks and NGOs, focused on vulnerability, adaptation, and funding. It developed adaptation approaches for policy-makers in order to strengthen the know-how in this area. The results were summarized in four publications. An international workshop was held in New Delhi in May 2006, to develop and evaluate indicators for the assessment of vulnerability. Other objectives were the exchange of expertise and linking local and national need with the international policy realm.

The project was supported by the European Commission and the British Department for Environment, Food and Rural Affairs (DEFRA).

### Source

- Building and Strengthening Institutional Capacities on Climate Change in Brazil, India, China and South Africa: http://www.basic-project.net/

## ACCA-Initiative

The Initiative Advancing Capacity to Support Climate Change Adaptation (ACCA) aims to raise the awareness of the public with regard to climate change adaptation measures. The initiative was launched in 2006 by the Climate Change Programme of the United Nations Institute for Training and Research (UNITAR). Globally, 19 pilot projects are underway.

The goal of the Indian pilot project is to inform the public about the consequences of climate change, particularly those consequences that require adaptation measures. It also aims to show the necessity of integrating adaptation measures into existing programs and the policy process. The target group is rural communities and regional decision-makers in the region of Bundelkhand, a poor, semi-arid region in central India. These rural communities are very vulnerable with regard to global warming as they highly depend on agriculture. Furthermore, the region is affected by unsteady rainfall, erosion, a lack of fertile soil, and forest dieback.

The project evaluated the vulnerability of the agricultural sector and the water supply. It also produced different documents for the communication of risks. Afterwards, the target groups were involved in a multi-disciplinary stakeholder dialogue. The goal is for stakeholders to help develop and implement pragmatic adaptation strategies.

### Source

- Adaptation Learning Mechanism: http://www.adaptationlearning.net/profiles/country/country.php?id=IN

## Integrated Water Management in Maharashtra

Climate change has made the management of natural resources more and more important for countries. In India, this is particularly relevant for the management of water resources, a key factor in the sustainable development of India and the livelihood of its rural population. The German Gesellschaft für technische Zusammenarbeit (GTZ) has numerous projects in
India that deal with the sustainable management of water resources. The projects build on a participatory approach as well as local technologies.

For instance, since 2006 the GTZ has organized projects in the state of Maharashtra. Maharashtra, a state in West India, is especially affected by an exploitation of ground water resources. Due to a lack of local capacity, public programs of the central government and the state government did not have sufficient impact.

So far the GTZ projects have reached over 150,000 people; 250 NGOs have participated in the initiative. At the moment, it is being determined whether the approach can be extended and transferred to other locations. The project partners are also working to support the Indian government in its effort to decentralize the water supply by involving local institutions.

Source

- The GTZ in India: http://www.gtz.de/de/weltweit/asien-pazifik/607.htm
CHINA: PROJECT CASE STUDIES

Protection of the Alpine Ecosystem in the Northwest Chinese Province of Yunnan

The alpine ecosystem in the northwest Chinese province of Yunnan is one of the most diverse in the world. It is not only a habitat for species that are threatened with extinction, like the snow leopard and the blue sheep, but it also serves the local people by providing a natural water reservoir and fertile meadowlands.

In order to avoid the destruction of this unique ecosystem from climate change and land exploitation, the Nature Conservancy and the Center for Biodiversity and Indigenous Knowledge (CBIK) have launched a project dedicated to the protection of this region and the development of the necessary adaptation measures.

The goals of the project, launched in 2003, are to identify the most urgent problems of the alpine ecosystem in Yunnan and to develop appropriate strategies to tackle them. Social, cultural, political and economic factors are incorporated in this process. Field studies have been used to collect data for a monitoring system that evaluates the local conditions on an annual basis.

Source
- Understanding the Alpine Mosaic: http://www.nature.org/wherewework/asiapacific/china/strategies/art13997.html

Strategy for the Adaptation of Agriculture

Through the Mainstreaming Climate Change Adaptation in Irrigated Agriculture Project, the Chinese government aims to foster the implementation of adaptation strategies in both conventional and hydroponic agriculture. In general, the project is intended to raise awareness of the need for such adaptation strategies and to build the required capacities and institutional foundations.

The project will integrate adaptation measures in the national Comprehensive Agricultural Development (CAD) Program, which represents the most important investment program in the field of agricultural hydroponics in China. The project consists of three parts with different targets. The first part identifies and prioritizes different adaptation measures. The second part is intended to test and evaluate these measures in selected areas, to advance their implementation within the framework of the Third Irrigated Agriculture Intensification Project (IAI3). The goal is to use the pilot project in order to improve the resilience of the Huang-Huai-Hai-Reservoir with regard to climate impacts.

The third part of the project aims to roll out the selected adaptation measures across the whole country. This step includes the provision of needed technical support and expertise, outreach activities to raise awareness of the public, and the preparation of a National Climate Change Adaptation Plan as an integral part of the CAD Program.

Source
Adaptation Strategies on the Local Level

The Provincial Programmes for Climate Change Mitigation & Adaptation in China aims to transfer China’s National Climate Change Programme to the local level, and to implement concrete measures in selected provinces.

In total, 14 provinces will be supported in developing local adaptation strategies, concrete courses of action, and emission reduction measures. In particular, the program is intended to develop and test new implementation approaches. The focus lies on provinces in the west and in the north of China.

For instance, on the Qinghai-Tibet Plateau, the project will help local authorities deal with the melting of the Himalaya glaciers. These glaciers, which are the second largest fresh water reservoirs worldwide, are melting much faster than other glaciers, in turn threatening the water supply of more than one hundred million people.

The program was launched in 2008 by an initiative of the United Nations Development Programme (UNDP), the National Development and Reform Commission (NDRC), the China International Centre for Economic and Technical Exchanges (CICETE), the Chinese Ministry of Commerce, the Norwegian government, and the European Union.

Source

## BRAZIL: PROJECT CASE STUDIES

### Pintadas Pilot Project: Adaptation measures in northeastern Brazil

Today, northeastern Brazil is confronted with many problems stemming from water scarcity and widespread poverty. Long-term climate projections show a further temperature rise for this region as well as longer periods of drought. Therefore, fast and comprehensive adaptation measures must be implemented in order to protect the livelihood of local farmers.

Between 2006 and 2008, a pilot project in the municipality of Pintadas tested how local adaptation measures could be designed. For example, effective sprinkler systems could help farmers to irrigate their fields during periods of drought. This example illustrates the aim of the pilot project to link climate change adaptation to anti-poverty measures.

In the second phase, a project launched in cooperation with Germany in 2008 will evaluate the approaches for four years. At the same time, specific proposals will be developed on how to transfer the experience gained in the Pintadas to other communities, as well as on how to effectively communicate adaptation strategies from other regions through networks.

**Source**
- Adaptation To Climate Change In Brazil: The Pintadas Pilot Project And Multiplication Of Best Practice Examples Through Dissemination And Communication Networks.

### Health Promotion in the Amazon Region: Fighting malaria

As in other countries, rising temperatures increase the threat of malaria and other tropical diseases in Brazil. The project Building Capacity for Health Vulnerabilities to Climate Change in the Amazon Region of Brazil is dedicated to public health initiatives in the Amazon region. It helps communities along the Amazon, the Tapajós, and Arapius fight diseases such as malaria and leishmaniasis (a parasitic infection spread by sand flies), reaching out to the most remote areas. In the Amazon region, “remote” can mean a 16 hours boat trip.

The project was initiated by SouthSouthNorth and implemented in cooperation with a local NGO. SouthSouthNorth is a public-private network for sustainable development. It was established in 1999 by researchers and government representatives during the fifth climate change conference in Bonn. SouthSouthNorth has adaptation and climate protection efforts underway exist in Brazil, Bangladesh, South Africa, Tanzania, Mozambique and Indonesia.

**Source**
- SouthSouthNorth: [http://www.southsouthnorth.org/](http://www.southsouthnorth.org/)

### Favelas in Rio de Janeiro: Used tires protect against mud slides

The slums (favelas) of Rio de Janeiro mainly consist of provisional housing built along the steep hillsides of the city. Forest clearing and excessive building activities have increased the frequency of erosion and mud slides. These housing developments experience massive structural damages, casualties, and fatalities during the rainy season. Extreme weather events will certainly increase these threats.

Given this challenge and the lack of available funding, a team of researchers from Canada and Brazil developed plans for building holding walls made of used tires. These walls are up to six meters high, and are one-third cheaper than walls made of concrete. In addition, these tire walls have the potential to actually be more effective in stopping huge mud slides.
Using tires to build retaining walls has the additional benefit of solving the city’s tire disposal problems. In Rio de Janeiro alone three million tires are disposed every year, with many dumped illegally or burned.

The project is supported by employees of the University of Ottawa (Canada) and the Catholic University of Rio de Janeiro.

Sources
- UNFCC Database on local coping strategies for adaptation: http://maindb.unfccc.int/public/adaptation/
- Stopping Landslides in Rio: Recycling Scrap Tires into Retaining Walls: http://www.idrc.ca/en/ev-5145-201-1-DO_TOPIC.html#Dr
Emerging Climate Change Adaptation Strategies Around the World


27 Umweltbundesamt (2008)


30 Bundesregierung (2008): Deutsche Anpassungsstrategie an den Klimawandel


36 Klimakommune NRW, Umweltminister Uhlenberg kürt Bocholt und Saelbeck zur NRW-Klimakommune, URL: http://www.umwelt.nrw.de/umwelt/klimakommune_nrw/index.php


38 It is important to note that projections of precipitation patterns, especially at the regional level, still involve great uncertainties.


40 Local Government Association et al. (2008):

41 Yorkshire and Humber Assembly, URL: http://www.yhassembly.gov.uk


46 In 2008 Scotland initiated the development of a Climate Change Adaptation Strategy through a public consultation process.
46 The Nottingham Declaration on Climate Change,
URL: http://www.est.org.uk/housingbuildings/localauthorities/NottinghamDeclaration,
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