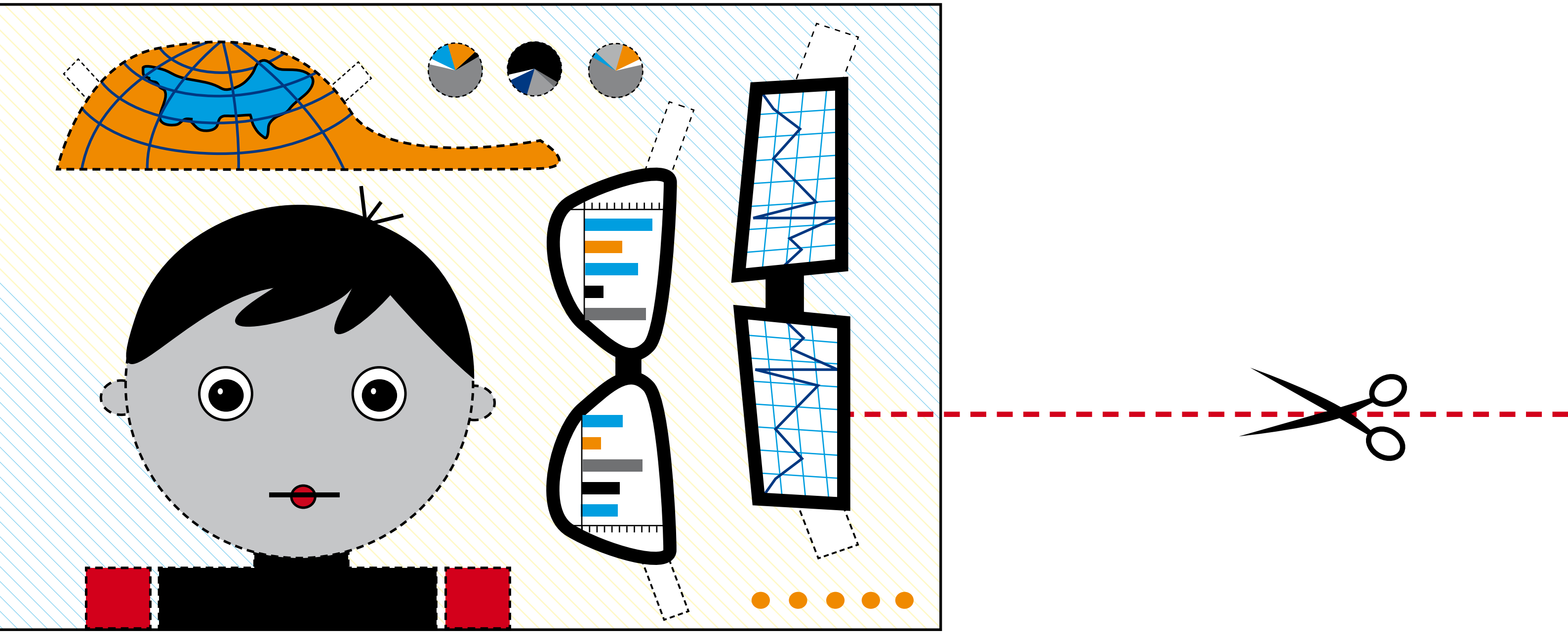


Climate Change Information for Effective Adaptation

A Practitioner's Manual

gtz

On behalf of
Federal Ministry
for Economic Cooperation
and Development

PIK

POTSDAM INSTITUTE FOR
CLIMATE IMPACT RESEARCH

Climate Change Information for Effective Adaptation

A Practitioner's Manual

Authors

Dr. Juergen Kropp, Potsdam Institute for Climate Impact Research, Head of the North-South Research Group

Michael Scholze, Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, Climate Protection Programme

Published by
Deutsche Gesellschaft für
Technische Zusammenarbeit (GTZ) GmbH
Climate Protection Programme
Postfach 5180
65760 Eschborn / Germany
climate@gtz.de
http://www.gtz.de/climate

Responsible
Dr. Juergen Kropp, Michael Scholze

Product planning and production control
Michael Wahl, Regine Hoffard

Language services
Alister Penny, Thomas McClymont

Design
Additiv. Visuelle Kommunikation, Berlin

Printed by
KlarmannDruck GmbH, Kelkheim

Eschborn, Mai 2009

Part I Background

Part II Practical Steps

BMU	German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety
BMZ	German Federal Ministry for Economic Cooperation and Development
CI: grasp	Climate Impacts: Global and Regional Adaptation Support Platform
°C	Degrees Celsius
CCE	Climate Change Explorer
CO2(eq)	Carbon dioxide, (eq) indicates that other GHG are considered as carbon dioxide equivalents
GCM	General Circulation Model
GHG	Greenhouse gases
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH
IPCC	Intergovernmental Panel on Climate Change
PIK	Potsdam Institute for Climate Impact Research
RCM	Regional Climate Model
SRES	Special Report on Emission Scenarios
UNFCCC	United Nations Framework Convention on Climate Change
WG	Working group

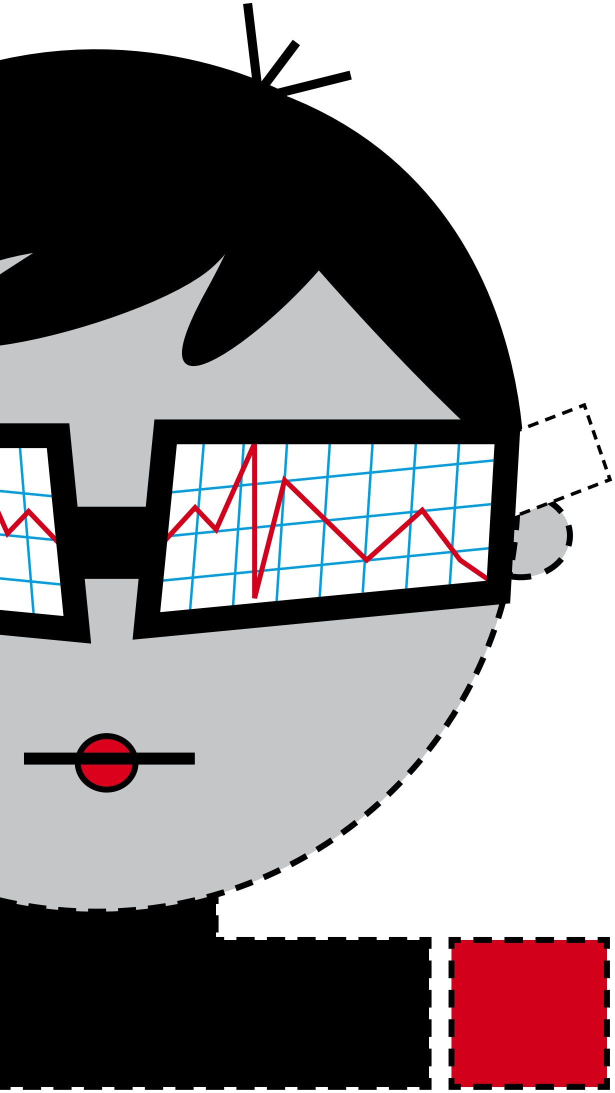
Foreword

Finding and implementing adequate responses to climate change poses a tremendous challenge to industrialized countries. Yet the challenges faced by decision makers in developing countries are even larger: While OECD countries can afford, in principle, to instigate the transition to sustainability - if they have the political will to do so -, developing countries' keep on perceiving fast economic growth as the primary goal, not least for stabilizing the political mood of their growing populations. Why should issues like climate protection or biodiversity support be on their agenda? On the other hand, developing countries are usually more vulnerable to environmental change due to their regional exposition to the forces of nature, weak institutions, and the poverty of a considerable fraction of their residents. Thus they face a dilemma: How can they grow in economic terms without contributing to the annihilation of the ultimate foundations of that growth? How can they benefit from capitalism if the (natural) capital stock tends to be destroyed in the process?

These are tantalizing questions that need to be addressed nevertheless. Science plays an increasingly important role in this context. In particular, it can provide newcomers in the field of climate change with a conveniently accessible "big picture" of the problematique and it can help development experts to explore the relevant solutions space. This holds true for the mitigation challenge as well as for the tasks associated with the adaptation to unavoidable environmental change as caused by past careless interference with nature.

Since development experts work at a very important interface, they are multipliers of knowledge and therefore can prepare the ground for an accelerated transition to sustainability. The main objective of the manual presented here is to enhance the capacity of those practitioners and decision makers in developing countries by translating relevant aspects of climate change research into their every-day working contexts. This guide describes the concrete steps of (i) how to obtain climate change information, (ii) how to interpret it adequately, and (iii) how to communicate the resulting knowledge in a careful and responsible way. I feel that this is precisely what decision makers, project managers and civil servants need and what was largely lacking up till now. In that sense, the guide can be seen as a first bridge between science and practice in a complex and difficult landscape.

Professor H.J. Schellnhuber, CBE
Director, Potsdam Institute for Climate Impact Research



Introduction

Objectives

There is no doubt that our climate is changing. This will pose huge challenges to nations, organisations, enterprises, cities, communities and individuals. Developing countries will suffer most from the adverse consequences of climate change, and some highly vulnerable regions and people are already being affected.

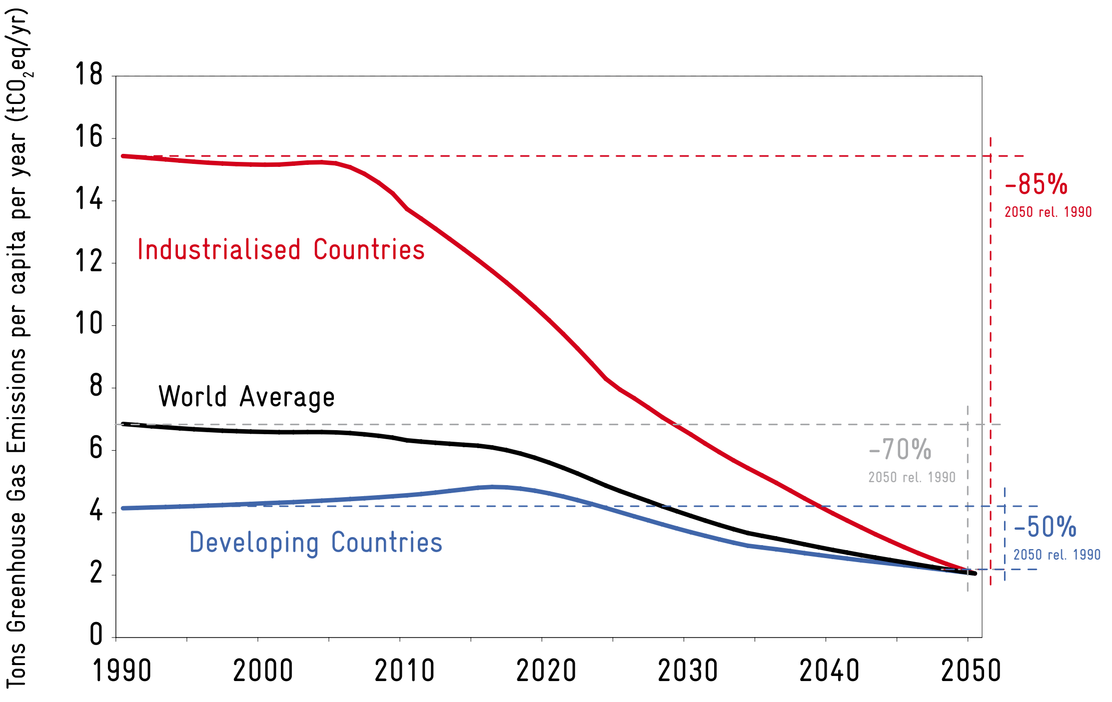
There is increasing agreement that if temperatures rise by no more than 2 °C the earth's integrity can be preserved and many of the potentially grave consequences of climate change could be avoided. This threshold is associated with per capita emissions of approximately two tonnes of CO_2 equivalents[1] each year. In terms of reducing greenhouse gases (GHG), the immense challenge this poses is shown in Figure 1. Industrialised countries, and soon also developing countries, need to sharply reduce their emissions.

---

[1] *GHG other than CO_2 are converted to CO_2 equivalents (CO_2(eq)).*

Figure 1:

One path to climate stabilisation below the threshold of a 2 °C rise in temperature. While for OECD countries a reduction of 85 percent is needed, the developing countries can slightly increase their emissions until 2017. Thereafter, they must also achieve a reduction of 50 percent by 2050. This goal is only achievable when emissions are constrained to 2 tonnes CO2eq/capita and year by 2050. For comparison, Australia today emits approximately 27 tonnes and the group of the LDCs 0.1 tones.



Per Capita Greenhouse Gas Emissions

If GHG emissions continue to rise, the worst case scenario of an increase of the global mean temperature of up to 6 °C is a real possibility. This would have disastrous consequences, yet even at the ambitious stabilisation target of +2 °C there would still be several regional negative impacts. Therefore, while it is imperative to aim for ambitious reductions in GHG emissions, there is also an urgent need to adapt to the unavoidable consequences of climate change.

In order to make the necessary adaptation to the consequences of climate change, decision makers must be well informed. At the international level, knowledge of the consequences of humankind's behaviour on our climatic system – presented, for example, in the latest IPCC assessment reports – is well-founded and adequate for policy makers. However, more specific information is needed for the implementation of concrete measures at the local level. It has been shown that the lack of such information is one of the severest bottlenecks to concrete action, in particular with regard to adaptation, but also for the implementation of integrated activities that would promote both mitigation and adaptation. This manual therefore focuses on ways to gather and interpret the relevant information for decision making. It is written for development practitioners from both governmental and non-governmental organisations.

Related to the issues listed above, important questions often asked by practitioners include:

What trends in climate change can be identified in a specific region?

Who is affected by it, and in what ways?

What sources of information exist as a basis for decision making?

How reliable is this information?

What options are there for adaptation and mitigation?

How should we communicate relevant information to others?

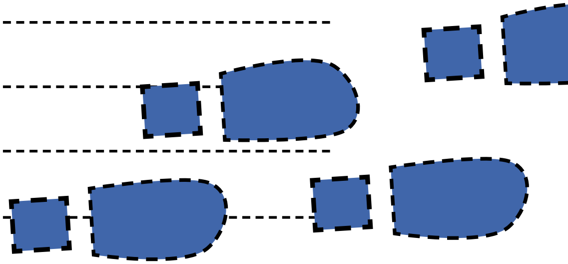
This manual is intended to serve as a guide; its aim is to extend the capacity of practitioners to find answers for themselves in any specific situation, using the best information available. As will be explained in more detail, a degree of uncertainty will always be involved due to the fact that in many cases no definite or comprehensive information about the impacts of climate change, or our vulnerability to it, can ever exist.

To be able to interpret climate change information we must first understand some of the approaches used in climate science. Therefore, Part I provides a brief overview of climate (impact) research, and gives a few essential definitions. It also describes basic climate modelling, as well as impact, vulnerability and adaptation analysis. It is therefore rather theoretical, and those already familiar with the science of climate change might choose to skip it. By contrast, Part II is more practical. Advice is given about how to gather a solid information base on regional climate change. It contains useful hints for those planning either stand-alone or integrated programmes, as well for anyone intending to mainstream climate change in their development activities, for example by "climate proofing" their investment decisions[2].

Adapting to and mitigating climate change calls for cooperation between the scientific and development communities. This manual was therefore jointly written by the North-South Research Group of the Potsdam Institute for Climate Impact Research (PIK) and the Climate Protection Programme for Developing Countries of the Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH. It is intended as a "translation" of relevant aspects of climate change science to meet the needs of development cooperation.

---

[2] *For more information on climate proofing, please see: http://www.gtz.de/climate-check*



Part I

Background to climate change research

① Definitions

What are adaptation and mitigation?

There are many different definitions of adaptation to climate change, which shows that there is no common understanding of the term (for an overview, see e.g. Schipper 2007). The latest IPCC assessment report, for instance, gives the following definition: "Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities." (IPCC 2007b, WG II, p. 869). In comparison the definition of mitigation is simple. It is just the reduction of GHG.

We can observe growing diversification of tasks in the work being undertaken by professional communities on adaptation and mitigation. However, interrelationships and synergies also exist between the two. Local mitigation strategies, such as the installation of solar panels, can also have a tremendous effect on adaptation. For instance, instead of collecting wood for fuel, people have more time for education—a key precondition for adaptation—and for livelihood improvement.

Figure 1:

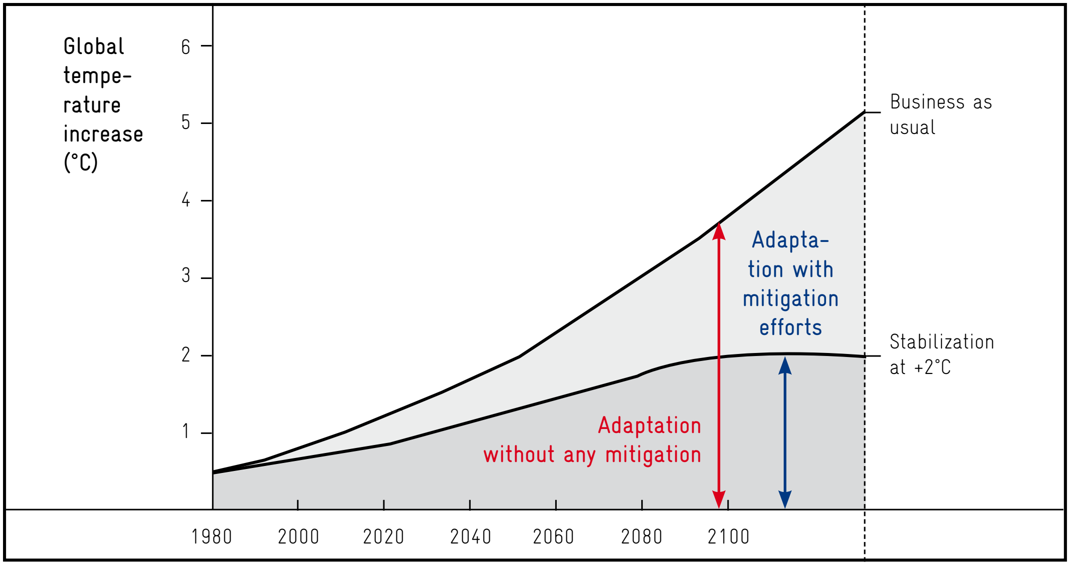
Adaptation and mitigation: two parallel strategies to combat climate change.

Two strategies are necessary to reduce the risks of climate change:

1. Mitigation – the causes of climate change are removed by reducing GHG emissions.
“avoid the unmanageable…”

2. Adaptation –
the effects of climate change are dealt with by coping with their negative impacts.
“… and manage the unavoidable”

The two strategies are interlinked: the more successful the first strategy is, the less the second one is required. The diagram below shows how a risk management approach to climate change should involve both strategies. This manual only addresses issues of adaptation.

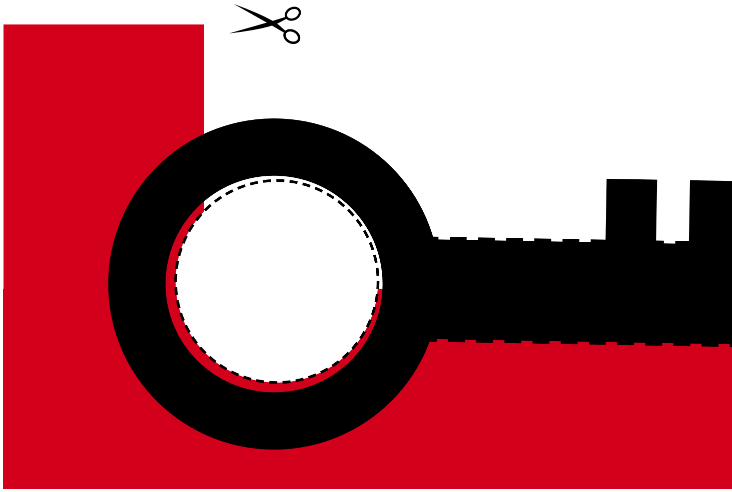


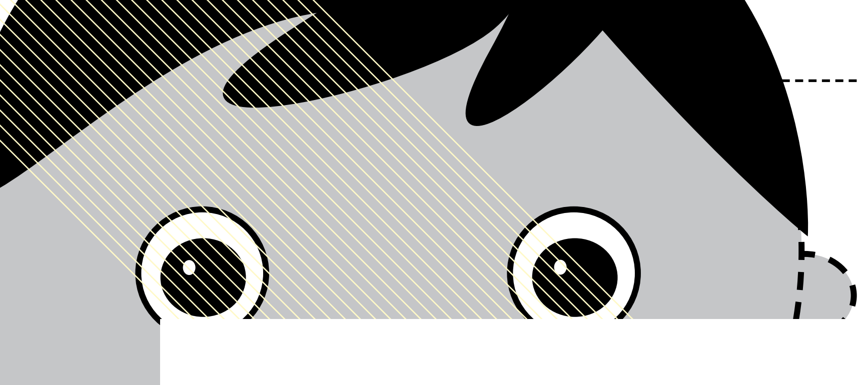
According to the IPCC, adaptation has a reactive component, i.e. learning from examples, and a proactive component, i.e. being prepared for coming events. The latter calls for anticipatory problem solving strategies, and is particularly important for the advisory services of experts in development cooperation.

Some theoretical terms used in the discussion about adaptation are illustrated by the example in Figure 2. The zigzag curve shows a potential development of precipitation in an African country. Such variables are often referred to as "climate stimuli". Historically, subsistence farmers have developed strategies to cope with varying levels of precipitation, which has resulted in a coping range.

However, weather events were sometimes too extreme to cope with (too much or too little rain), and the farmers lost their crops. In other words, they were vulnerable to these extremes, even before the climate changed (stationary climate). With the changing climate, the trend in the curve is downwards (decreasing precipitation) and conditions exceed the coping range more often.

This is the point at which adaptation becomes relevant. Using climate change information in a proactive manner and applying measures such as improved watershed management or growing drought resistant crops, the coping range of the subsistence farmers can be expanded. Nevertheless, there will be limits to the adaptation and, in the future, some areas might no longer be suitable for agricultural production.





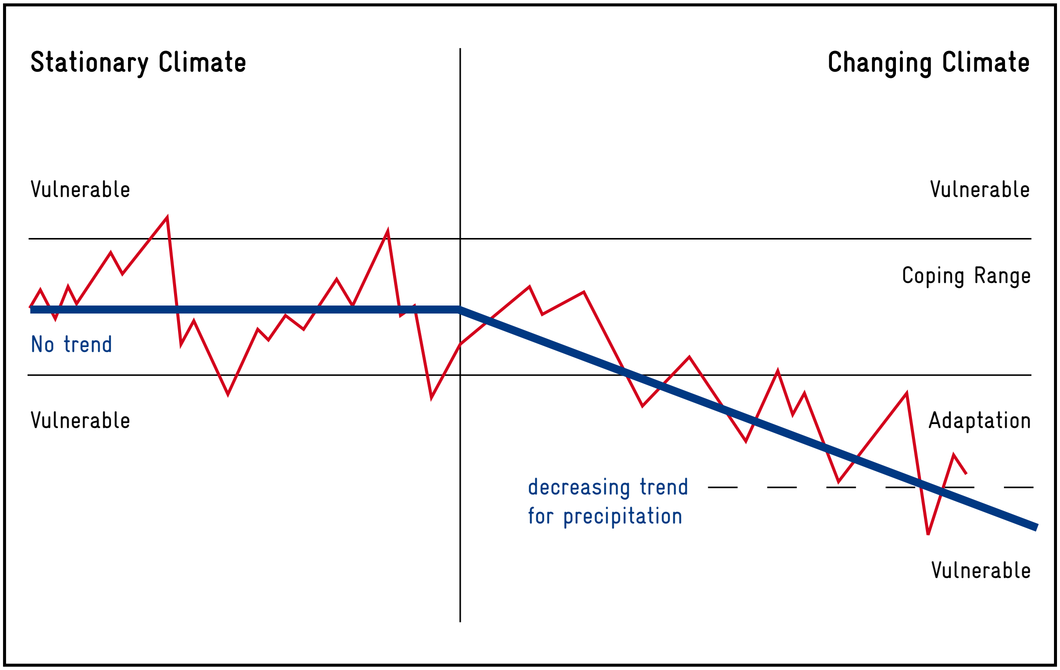


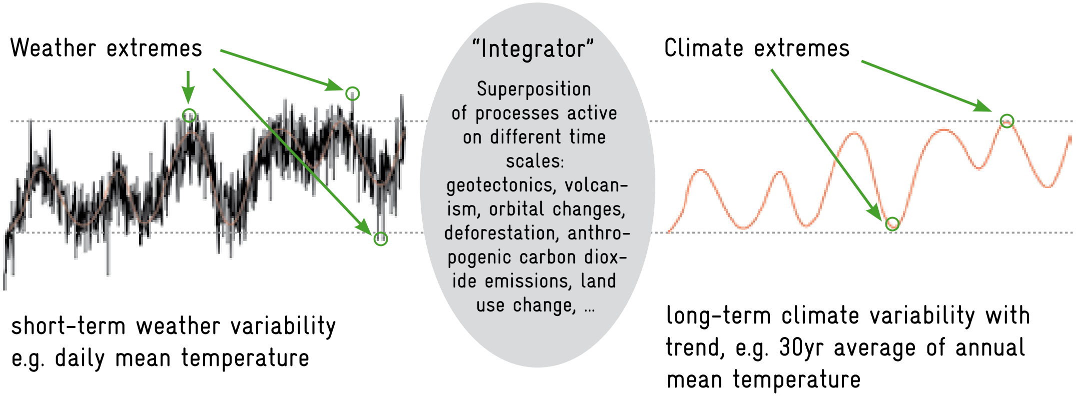
Figure 2:

Idealised concept of adaptation in the context of decreasing precipitation introducing some key terms. It shows that adaptation broadens the coping range.

Weather and climate

For a deeper understanding of climate change it is essential to distinguish between weather and climate which are mutually exclusive. "Weather" is the day-to-day state of the atmosphere in terms of temperature, moisture content and air movements; it derives from the chaotic nature of the atmosphere and is unstable as it is affected by small perturbations. The term "climate", on the other hand, is a scientific concept. It deals with statistics, such as the averages of all weather events, over a long period of time (normally 30 years). Whereas the weather can be directly perceived by people, climate cannot. Or, as a popular phrase puts it: climate is what you expect, weather is what you get. One question often raised is, how scientists can project the climate 50 years ahead when they cannot predict the weather just a few weeks from now. There are important differences between the two kinds of forecast. Climate scenarios are "what if" projections of the future climate, corresponding to certain emissions scenarios, made to guide policy and decision makers. They depend on fundamental physical laws, on assumptions about people's behaviour, demography, north-south equity and how fast clean technologies will be implemented. Climate is concerned with slow changes in the statistical properties of weather over longer time scales, resulting from changes in major atmospheric compounds (greenhouse gases). Our projections are therefore feasible as they are based on our understanding of the dynamics of climate, of its major constituent parts (e.g. the biosphere and humanity), and other major forces such as volcanism. By contrast, weather is chaotic by nature. Weather forecasts can therefore only predict conditions for the next few days, based on the starting point of a specific atmospheric state (the current weather situation). Another misconception is that a cold winter disproves global warming. However, it is the nature of weather to be highly variable. This variability can be analysed for example, using temperature probability curves. The probability of an extreme event occurring only every 100 years can be estimated using the one percent of the curve at its right or left edge (dashed line in Figure 4a). Quantitatively, the probability of an extreme event can be expressed by the size of the area below the curve. As shown in Figure 4, climate change is shifting the probability curve for the temperature to the right. This increases the probability of extreme warm events (shaded area on the right) and decreases the probability of extreme cold events (shaded area on the left). In some cases we even expect that the variability (the shape of the curve itself) is changing (Figure 4b). Thus, cold winters in some cases are still possible although they do become less probable.

Figure 3: Climate system as an "integrator" of atmospheric variability.



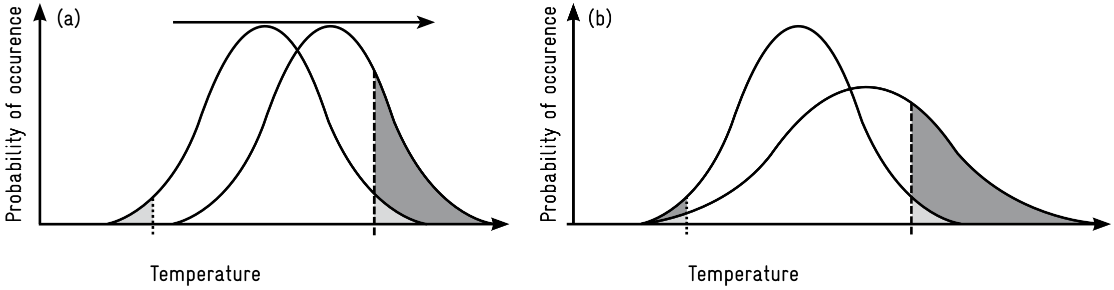
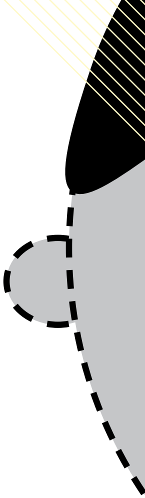


Figure 4: Shifting climate variability during climate change



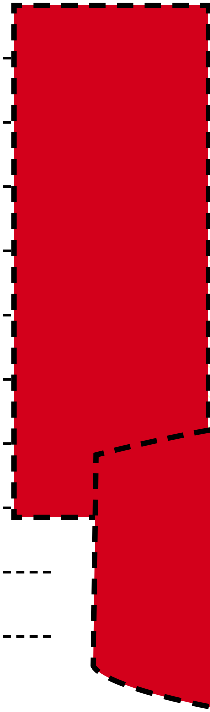
② **Generating** climate change information, and the role of uncertainty

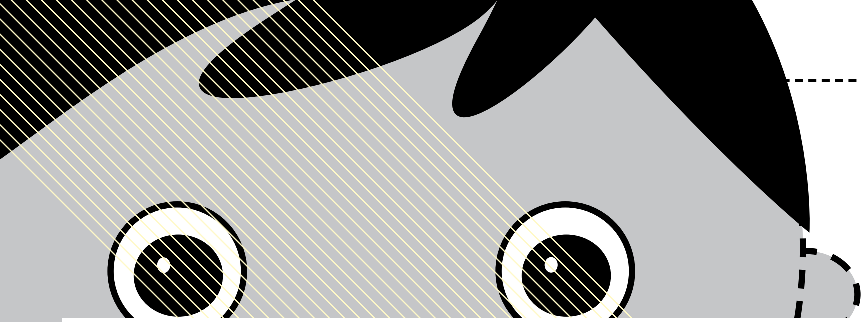
The earth's climate system

The physics underlying the climate system is well known and widely understood. The earth's climate is determined by many factors, processes and interactions at a global scale (see Figure 5). Important elements include the biosphere, the ocean, sea ice, clouds, and the ways in which these interact. One important phenomenon in the earth's atmosphere is the well known greenhouse effect. This natural effect is responsible for the comfortable living conditions on earth, with a mean global temperature of 15 °C. Without an atmosphere, the mean temperature would be approximately 30 °C lower.

Today, human beings have also become a component in the earth's system, driving and accelerating global warming through the intensive release of GHG into the atmosphere. The warming itself leads to feedback mechanisms, such as the release of further GHG like methane, which was previously trapped in permafrost soils.

Other forcing factors also exist that are beyond humankind's influence. Examples of these include variations in solar radiation and volcanic activity, and fluctuations in the earth's axis and its orbit around the sun. These are exogeneous events, partly responsible for the changes which have occurred between ice ages and the interglacial periods. They take place over a larger time frame (tens of thousands of years or more), and must be clearly differentiated from climate change that is induced by human beings. The latter can be prevented by taking adequate action.





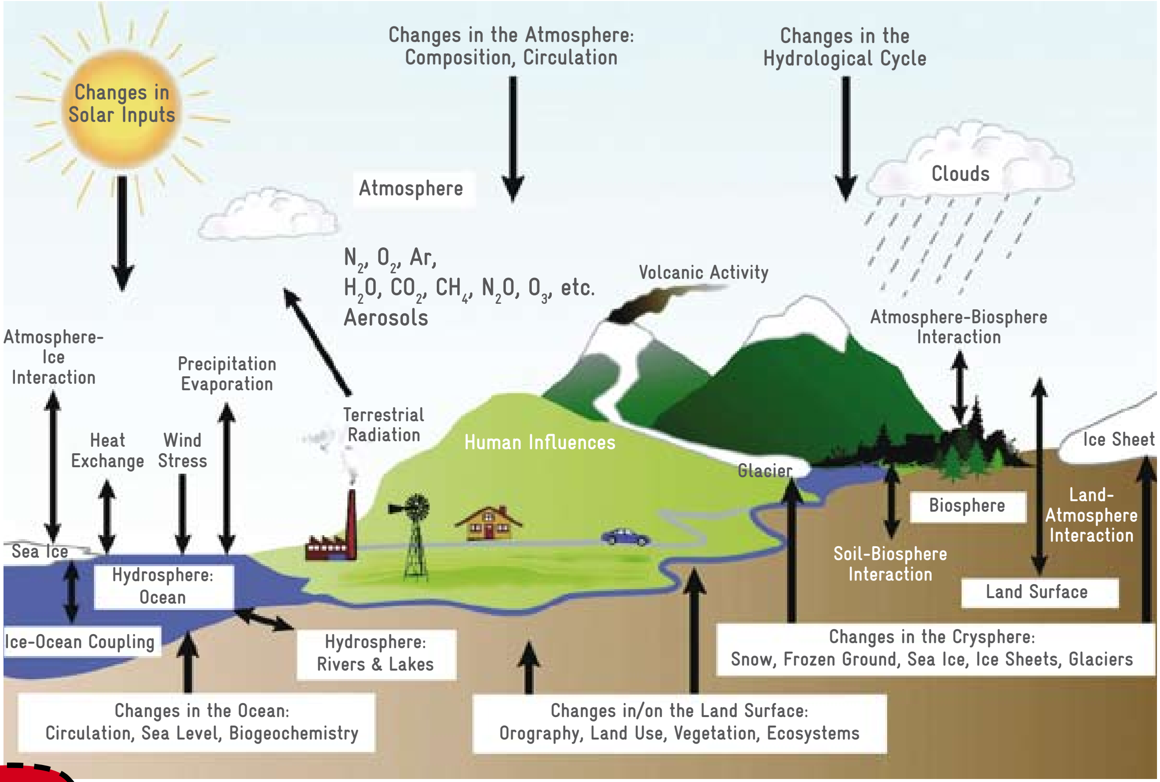


Figure 5:

Schematic view of the components of the climate system, their processes and interactions

Source: IPCC, 2007a

The scientific approach to generating future climate information

The scientific method for gathering relevant climate change information can be divided into the following steps: Global emission scenarios (SRES scenarios[3]), based on so-called narrative storylines for humankind's development over the next 100 years, describe how GHG emissions might develop in the future. The associated emission pathways are used as the basis for simulations using general circulation models (GCMs)[4], which calculate the interrelationship of the elements of the earth system and thereby project future climate trends. Regional climate models (RCMs) are based on the results of the GCM, and project the climate in more precise geographical detail. The results of the GCM and the RCM are (regional) climate change scenarios (not emission scenarios!) which describe, for example, how temperature, precipitation or other climatic parameters are expected to change in an area under investigation. The effects of such climate scenarios on societies and ecosystems are investigated further in climate impact studies. These use vulnerability assessments and the analysis of adaptation strategies to provide stakeholders with relevant knowledge. Historical knowledge, i.e. experiences from historic events, can be of great value for this, for instance by helping to understand extreme events and for the identification of measures to adapt to their increasingly frequent occurrence in the future. Besides this top-down, scientific approach, empirical local knowledge of climate variability and adaptation to it is also available. Such grassroots information is an important complement to the entire scientific top-down approach. An overview of this process is given in Figure 6, and all the steps are described in more detail below.

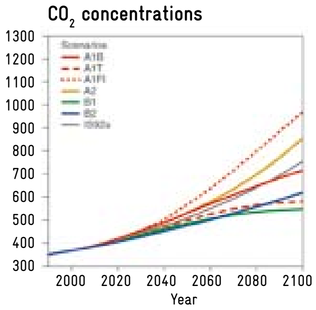
---

[3] *SRES: Special Report on Emission Scenarios*

[4] *often also known as global climate models*

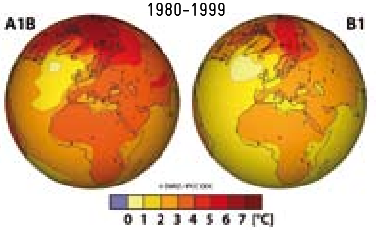
Figure 6:

Steps to generate future climate information

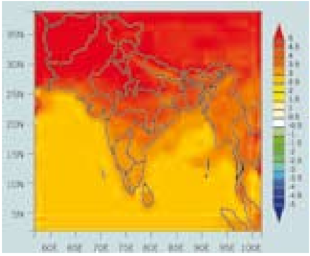


Global emissions scenarios

Temperature Change for 2080-2099 compared with 1980-1999



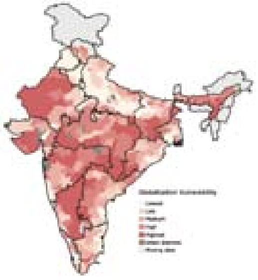
Global Climate Models (23 in IPCC)



Regional Climate Models

Knowledge from Historical Events →

Local Knowledge and Experiences →



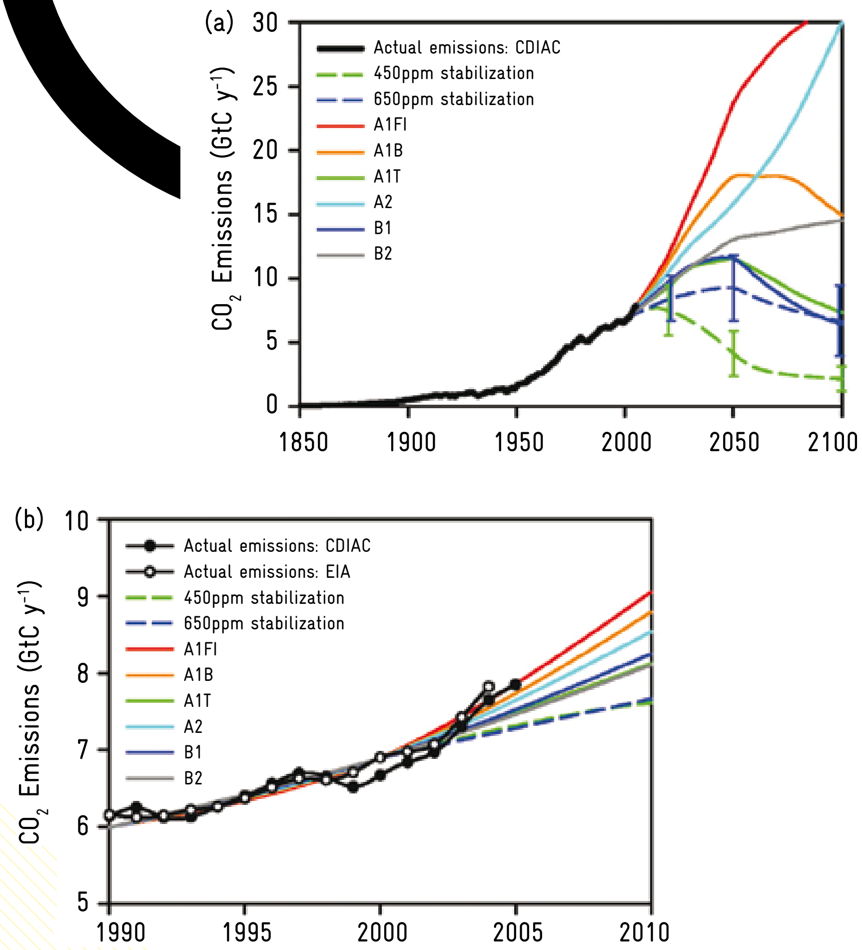
Impact, Vulnerability & Adaptation Analysis

Sources: IPCC, DKRZ, DEFRA, O'Brien K. et al. (2004)

A) EMISSION SCENARIOS

Between 1970 and 2004, GHG emissions increased from 28.7 to 49 gigatonnes of CO_2eq per year – a rise of 70 percent. Will this rapid increase continue in the coming decades? Future anthropogenic emissions will be determined by driving forces such as demographic and socioeconomic development, and technological change. A global population of 15 billion people; a mainly fossil fuel-based economy; an adjustment of income levels to match those in developed countries by 2050: all these things would boost GHG emissions. By contrast, a transformation to a low-carbon economy with seven billion people and moderate increases in income would stabilise GHG emissions. Both scenarios are plausible. The emission path humankind takes will depend on decisions made today and in the future. No one can predict what these decisions will be.

In other words, these emission scenarios present alternative visions of how the future might unfold. They are grouped into four "families", each of which contains scenarios that resemble one another in some respects. Each climate model run is based on these emission scenarios, and therefore rests on specific assumptions about future emissions. The projected CO_2 emissions for each of these scenarios are shown in Figure 7. A more detailed description of the assumptions behind these emission scenarios can be found in Annex 1.



50yr constant-growth rates to 2050

A1FI: 2.4%
A1B: 1.7%
A2: 1.8%
B1: 1.1%

Observed 2000-2006: 3.3%

Figure 7:

Different IPCC (SRES) emission scenarios, and resulting CO_2 emissions (coloured lines) till the year 2100 (A) and 2010 (B). The black lines represent actual emissions and show that emissions of the last years were – depending on data sources – at the upper end or even beyond the “worst case” emission scenarios.

Source: Raupach e. a. (2007)

B) GLOBAL CLIMATE MODELS

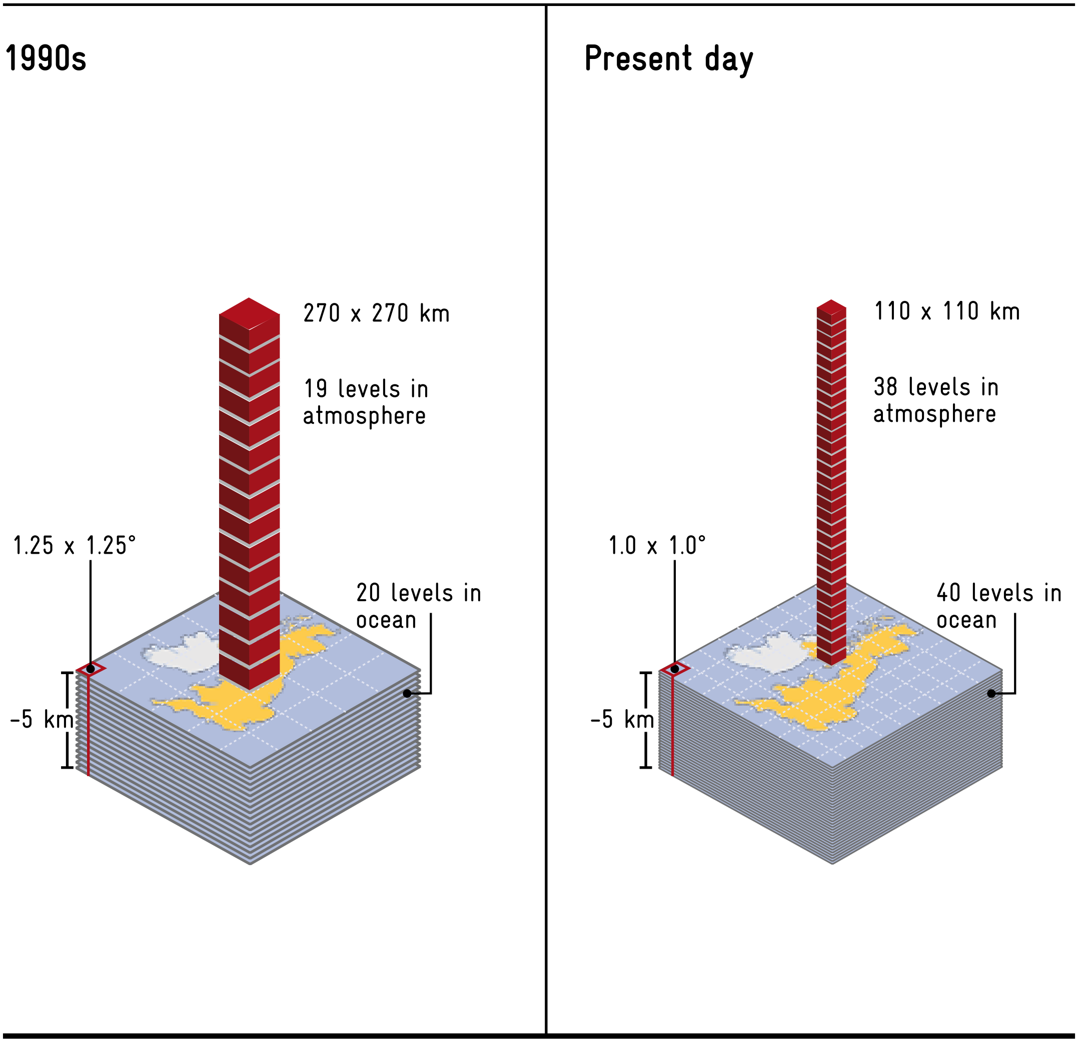
Atmosphere ocean general circulation models—general circulation models (GCM) for short or often also called global climate models—are computer models that divide the earth into horizontal and vertical grid cells. Each of the cells represents a specific climatic state for a specific time, based on a set of equations. Large computers are needed to calculate the mathematical equations for each cell, describing major components of the climate system and their interactions over time. The length of the edges of the grid cells range in size from approximately 100km to 200km, and are divided vertically into several levels covering both the ocean and the atmosphere (see Figure 8). Higher resolution is limited not by a lack of scientific knowledge but by the lack of adequate computing power. As new supercomputers become ever more powerful (they have increased by a factor of a million over the three decades since the 1970s), the resolution of the GCM is expected to increase further in the future. Today's GCM already count as the most complex and comprehensive computer models ever developed [5].

23 different models were taken into consideration for the latest IPCC assessment reports. These vary according to the accentuation of the physical processes represented, and in terms of the grid resolutions. The results of all the models are generally consistent, which enormously increased their apparent trustworthiness, as shown in the latest IPCC (2007) report.

---

[5] *For more information on these computer models and their results see a video produced by Japanese scientists: http://www.team-6.jp/cc-sim/english/*

Figure 8: Progression of climate models



Source: Hadley Centre

C) REGIONAL CLIMATE MODELS

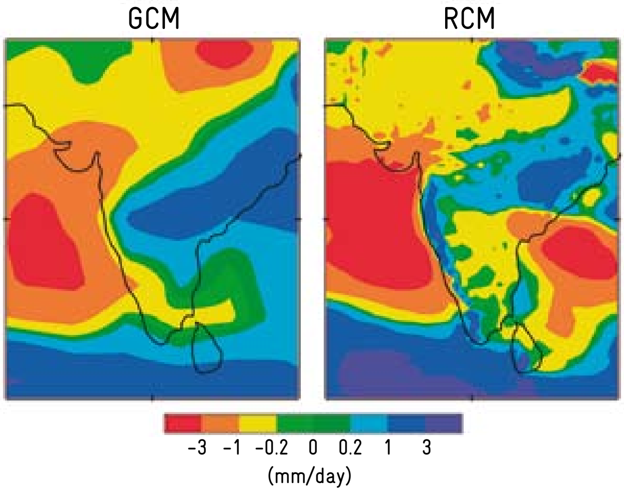
The global models often produce results that are inadequate for use in local assessments. Local climates are influenced significantly by smaller-scale features and processes, such as mountains, forests or lakes, the heat-island effect of large cities, etc. These features are not represented in detail in global climate models due to the low resolution. For instance, in a GCM, large mountain ranges like the Alps or the Andes are covered by just a few grid cells. More localised differences between regions at higher and lower altitudes, or specific climatic conditions in valleys cannot be represented. For this reason, regional climate models (RCM) have been developed. Their resolution ranges from 10 to 50 km (see Figure 9) or refers to the station distribution in an observed area. There are two main types of regional climate model: statistical and dynamic[6]. The former analyse empirical data from weather stations and extrapolate the results into the future by using climatic trends taken from the GCMs. They have the advantage of being partly based on empirical local climatic knowledge. Here it is a disadvantage that, in developing countries, empirical climate data are often not available for long periods without gaps, due to a lack of observational coverage (see Figure 10). Therefore dynamic models are usually applied (e.g. PRECIS, CCLM, REMO), which work in a similar way to the GCM. They are nested into coarser GCM, which means that they use GCM outputs for calculating a potential climate evolution for the region under consideration. The simulation time needed for the regional models can be longer than that for the GCM because of the additional processes being represented in more detail. A list of well-known RCMs can be found in Annex 5.

---

[6] *For a detailed description of the methods see PRECIS Handbook, p. 14: http://precis.metoffice.com/docs/PRECIS_Handbook.pdf*

Figure 9:

Comparisons of GCM and
RCM



Source: Hadley Centre 2004, Precis Handbook p. 18

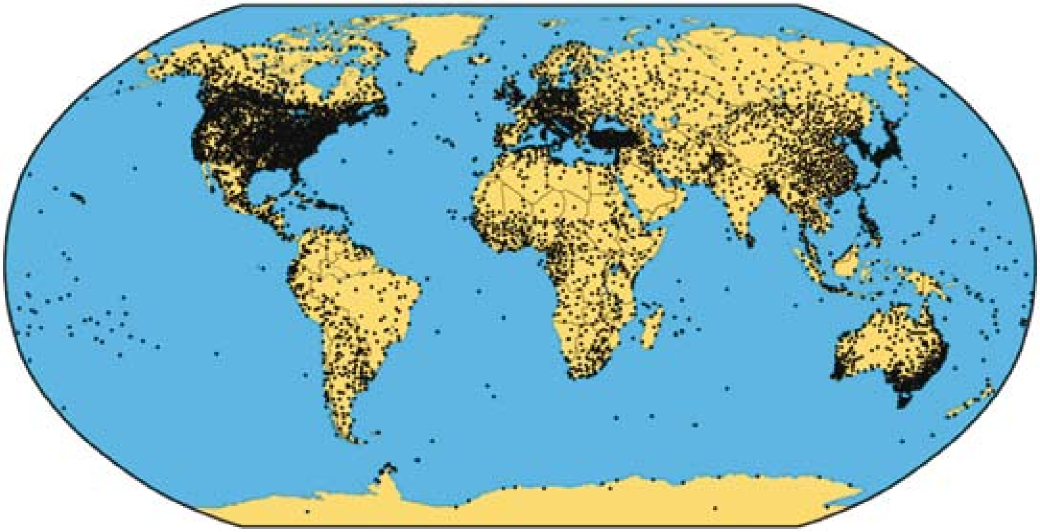


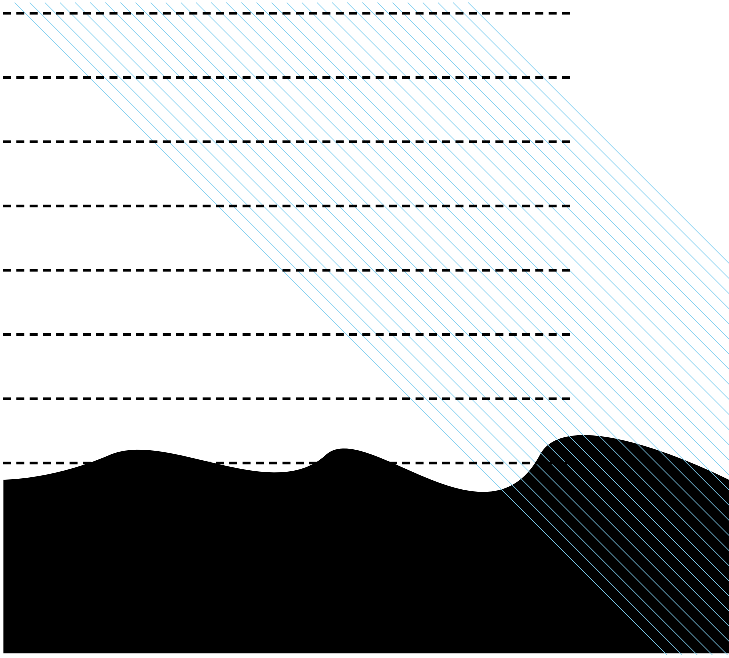
Figure 10: Typical monthly coverage of weather observations.

Source: NOAA

D) IMPACT, VULNERABILITY, AND ADAPTATION ASSESSMENT

What does it mean if the temperature rises by 2 or 3 °C, if the precipitation decreases by 30 percent, or if the sea level rises 50 centimetres? For decision makers to receive relevant information, data derived from GCM and RCM must be placed in the context of physical, socioeconomic and ecological processes, and the potential consequences of a changing climate must be deduced. A variety of different methodologies is available for this, the success and quality of which should be judged in terms of their comparability, transferability and transparency. An overview of the main approaches (impact, vulnerability, adaptation and integrated assessments) is given in Table 1. It is difficult to make clear distinctions between them. Vulnerability assessments play an important role in identifying potential sectoral or regional hot spots for the impacts of climate change. A non-comprehensive list of these scientific methodologies (which in most cases require technical knowledge and expertise) can be found on the Internet[7].

As climate change is often not the only driver of change, some more sophisticated impact, vulnerability and adaptation assessments also include future socioeconomic, land-use and technology scenarios in an integrated approach. The amount of detail involved varies widely, ranging from short studies to intense and long-lasting scientific research, including participatory processes with different stakeholders. Thus, the costs of performing assessments can also vary significantly (see also Part II). An example of a global impact analysis is given in Figure 11a and b.



---

[7] *http://unfccc.int/adaptation/nairobi_workprogramme/compendium_on_methods_tools/items/2674.php*

Table 1:
Different approaches taken by climate change impact, vulnerability and adaptation assessments

	Approaches			
	Impact	**Vulnerability**	**Adaptation**	**Integrated**
Scientific objectives	Impacts and risks of the future climate	Processes affecting vulnerability to climate change	Processes affecting adaptation and adaptive capacity	Interactions and feedback between multiple drivers and impacts
Practical aims	Actions to reduce risks	Actions to reduce vulnerability	Actions to improve adaptation	Global policy options and costs
Research methods	Standard approach Drivers-pressure-state-impact-response methods Hazard-driven assessments	Vulnerability indicators and profiles Past and present climate risks Livelihood analysis Agent-based methods Risk perception including critical thresholds Development/sustainability policy performance Relationship of adaptive capacity to sustainable development		Integrated assessment modelling Cross-sectoral interactions Integration of climate with other drivers stakeholder discussions linking models across types and scales Combining assessment approaches / methods

Source: Adapted from IPCC (2007b)

E) KNOWLEDGE OF HISTORICAL EVENTS

In some cases, historical events can give a clear picture of the impacts of climate change. One prominent example is the European heat wave of 2003. This extreme event caused a death toll of at least 30,000, mainly elderly people. Viewing this against climate projections, one can see that an event like this could be a normal occurrence by the 2040s, and that by the end of the century it might even count as cold (see Figure 12). Therefore, one can benefit a lot from such knowledge when planning to adapt to future conditions[8].

Figure 11a: Poverty Degradation Spiral (1999)

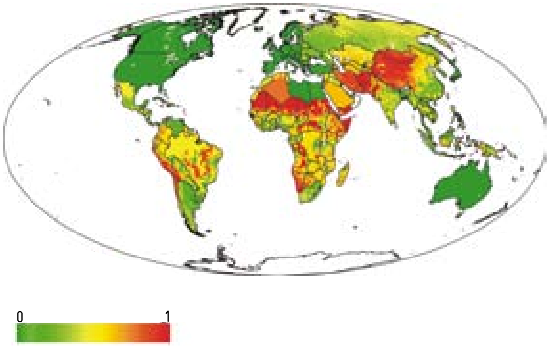


Figure 11b: Aggrevation of the mechanism though climate change

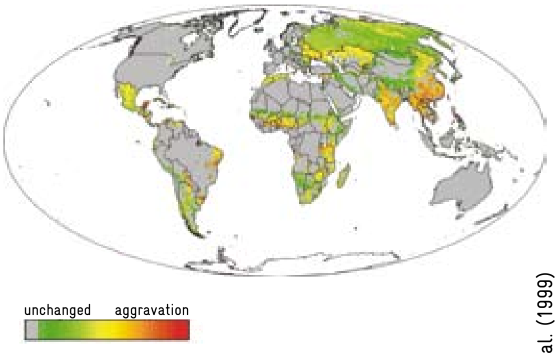


Figure 11a shows a global assessment of the so-called poverty degradation spiral. This describes a situation in which subsistence farmer on marginal land can either expand or intensify their agricultural practices to combat poverty; if they are unsuccessful they cause further soil erosion, which leads to a downward spiral. The map shows regions which are disposed to this problem (1999). Figure 11b shows the regions in which this situation is aggravated as a result of climate change.

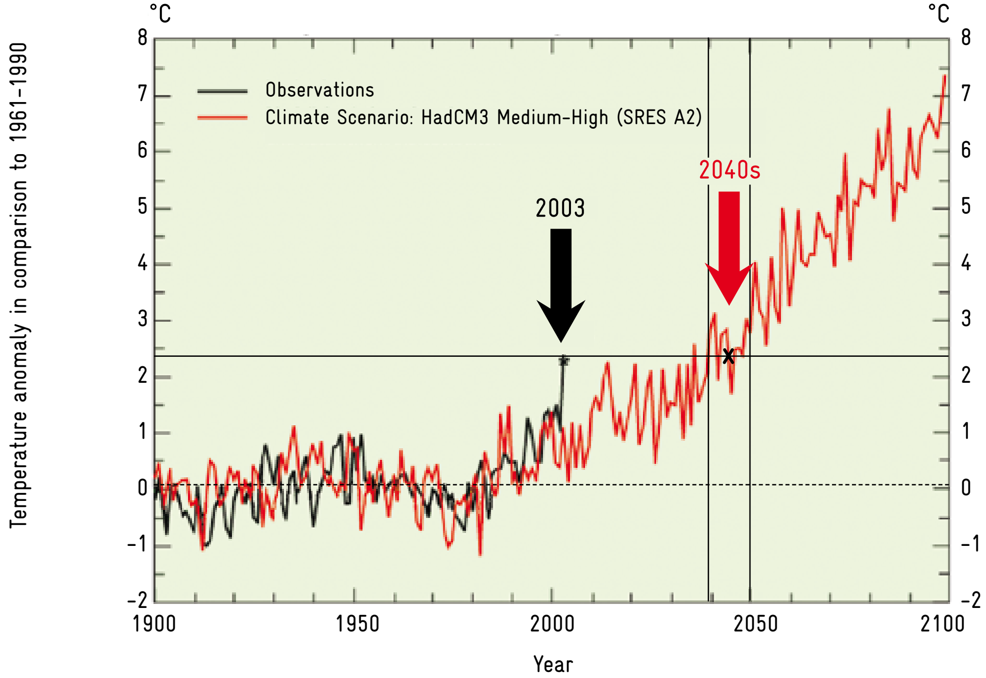
Source: PIK/Lüdeke et al. (1999)

---

[8] *See also IPCC 2007, WGII, p. 146 and on summer heat an article in Science: http://iis-db.stanford.edu/pubs/22374/battisti_naylor_2009.pdf*

Figure 12:

European summer temperatures 1900-2100:
Comparison of a climate scenario and the climate signal of the European heat wave 2003



June–August temperature anomalies (relative to 1961–1990 mean, in °C) over parts of Europe. Shown are observed temperatures (black line), modeled temperatures from HadCM3 simulations (red line). The observed 2003 temperature is shown as a star. The figure shows that an event as the summer 2003 heatwave in Europe will be common in the 2040s.

Source: Stott et al. (2004)

F) LOCAL (NON-EXPERT) CLIMATE KNOWLEDGE

An important source of information that is often neglected is the knowledge possessed by local people. Worldwide, over a period of millennia, humankind has responded to catastrophic weather events and changing climatic conditions. Although this knowledge is sparse, and in some cases highly subjective, it can be very informative. It has the advantage of being locally and regionally specific and comprehensive. It may range from specific weather parameters to local vulnerabilities and adaptation strategies. Furthermore, it can help to assess the plausibility of scientific findings; it supports learning and provides hints for adequate action.

Uncertainty and risk assessment

It is better to be vaguely right instead of precisely wrong (Karl Popper)

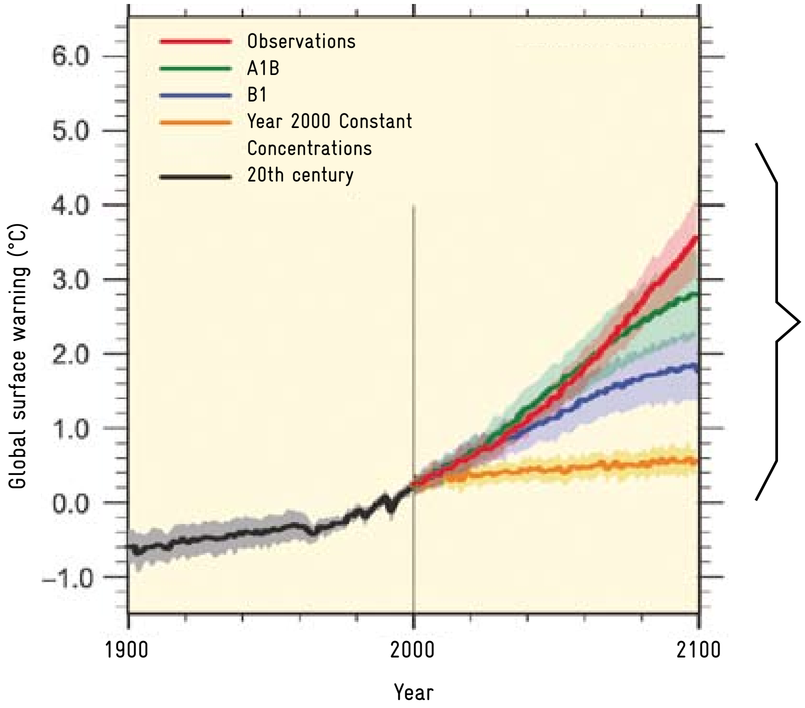
Science does not give exact or certain forecasts of the future climate, and it will never be able to do so. But it would be wrong to conclude that no action on adaptation can therefore be taken. Uncertainty is not the same as ignorance; it is something that confronts many decision makers—not only in the field of climate change. Companies have to take strategic decisions despite high levels of uncertainty about future markets. Politicians pass new laws without knowing exactly what effects they will have. In our day-to-day life we take many decisions without having enough validated information. What would one rather believe, a scientist's projection of the climate for the next 50 years or an economist's stock market prognosis for the next five years? To assess uncertainty—to judge its magnitude and find out its origins—is ultimately the responsibility of the decision maker. Climate research simply provides all the relevant information.

Therefore, the challenge that faces adaptation practitioners is to manage rather than overcome the uncertainty!

There are several reasons for uncertainty about climate change information. The single largest of these is the fact that we cannot predict the future level of GHG emissions. Many different "emission futures" are possible. Scientists allow for this by using different emission scenarios (as described in Chapter 3.2.1 before). By comparing the climate model outcomes for the different emission scenarios, the range of possibility for future climatic developments can be seen. For the global level, this is illustrated in Figure 13.

Figure 13:

Global multi-model averages of surface warming (relative to 1980–1999)



Possibility range: illustrating the uncertainty for each of the IPCC models (the coloured envelopes) and uncertainty about mankind's behaviour (range of emission scenarios)

Global surface warming for the three scenarios A2, A1B and B1, as well as year 2000 constant concentrations. Shading denotes the plus/minus one standard deviation range of the annual averages for the individual models.

Source: IPCC (2007a)

As seen in the shading around the lines, individual climate models also contain uncertainties. Each model is just an approximation of reality, as the complexity of the entire earth system renders full analysis impossible as it would be too time consuming. Nevertheless, climate models are constantly improving. While the early GCM only looked at the atmosphere, the latest ones incorporate all major components such as land surface, oceans, sea ice, aerosols and the carbon cycle. The physics underlying these components is mostly understood, yet some elements of the climate system, such as clouds or monsoons, are still difficult to model. It is important to allow for the fact that uncertainties differ in regard to region and climate stimulus. Comparing the models is one way of dealing with this type of uncertainty, and it is a good basis for risk assessment. This is shown in Figure 14.

The colours in the diagram represent mean changes in temperature, precipitation and air pressure for summer (above) and winter (below). The stippled areas are important as they denote the regions where almost all models produce similar results (average of all models). One can see that:

- for some climatic variables (e.g. temperature) the models largely agree on the direction of change and magnitude for most parts of the world (stippled).
- for other climatic variables there is less certainty (no stippled area). The coloured area nevertheless gives an indication of the expected direction of change.

For the impact, vulnerability and adaptation assessments, judging the effects that climate change will have on socioeconomic and ecological systems is a complex task. Other drivers of change, such as overpopulation, migration, resource overuse and economic development often play an important role as well, which provides another source of uncertainty. A prominent example of how these complex networks of interrelation can be assessed is the so-called syndrome concept (Schellnhuber et al. 1997), which tries to assess patterns of global change on various scales[9].

---

[9] *See: http://www.wbgu.de/wbgu_syndromkonzept_en.html*

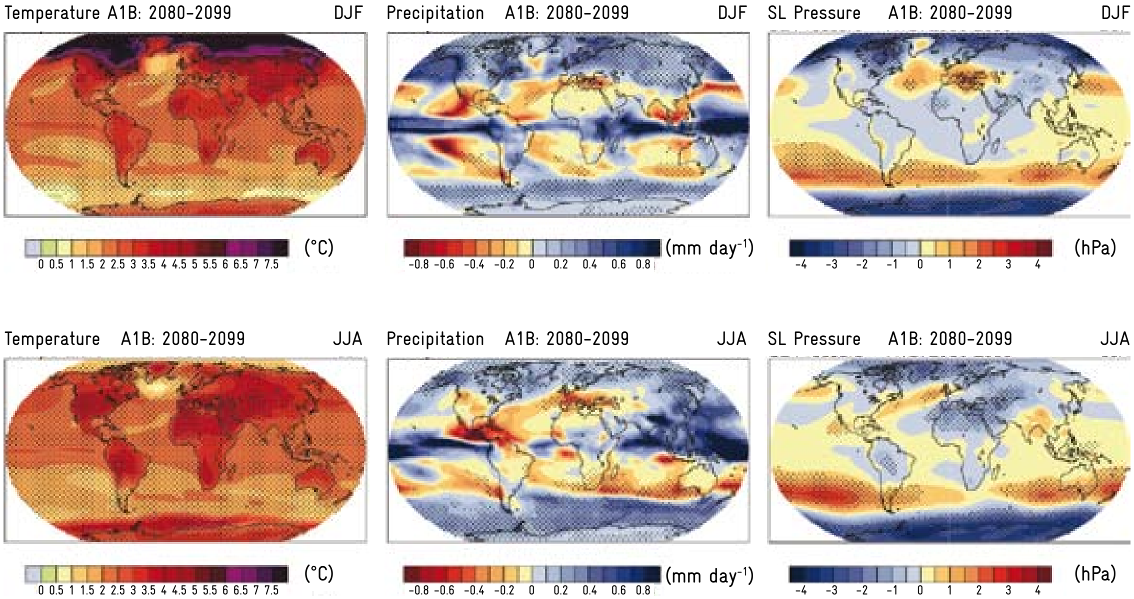
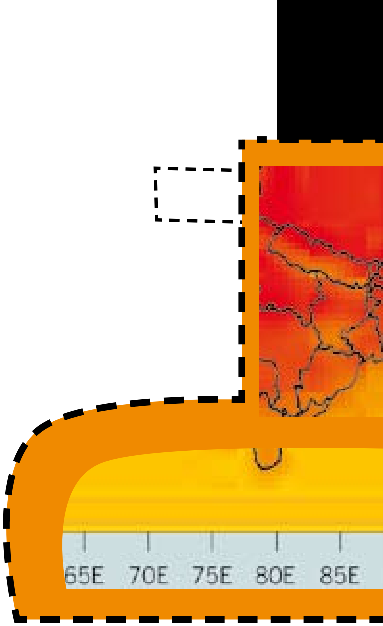


Figure 14:

Multi-model mean changes in temperature, precipitation and pressure for an A1B emission scenario. The upper map shows winter (DJF = December, January, February) the lower summer (JJA = June, July, August).

Source: IPCC (2007a)



Part II

Practical Steps

While Part I presented the general background of basic concepts, climate change science and its methods, Part II provides practical information to guide you in the following activities:

- **Accessing** climate change information
- **Interpreting** climate change information and dealing with uncertainty
- **Communicating** climate change information

The sub-chapters are complemented by several annexes to this manual.

① Accessing
climate change information

There are various ways to collect climate change information, which are grouped here into three approaches. They should be seen as complementary; they differ mainly in their level of detail, expert involvement and related costs. A short summary of strength and weaknesses is given for each approach.

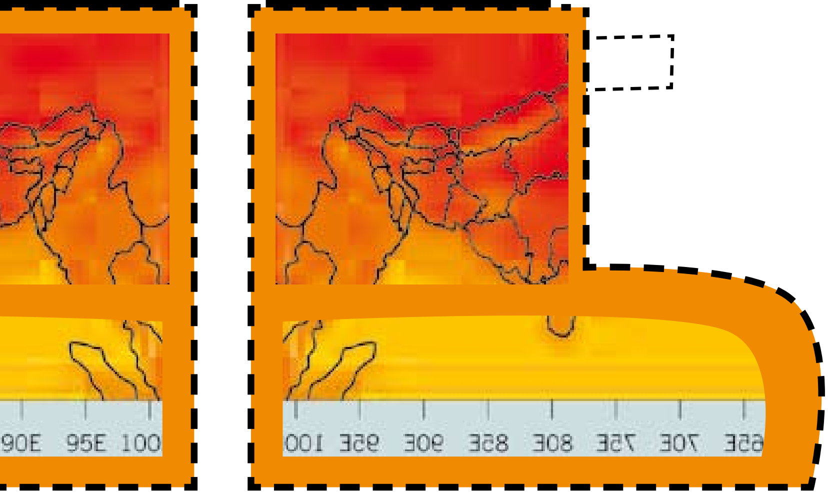


Table 2:

Most important
climate change related stimuli

○ increased temperature (including seasonal changes)

○ more intensive and frequent storms

○ sea level rise

○ more heat waves

○ more cold spells

○ more droughts

○ more flooding, and more extreme floods

○ more extreme rain (including seasonal changes)

○ change in annual or seasonal water availability

○ accelerated melting of glaciers

○ melting of permafrost

Rapid literature assessment

Rather than generating your own climate change information, try to find existing material on the internet and obtain it from resource persons or institutes. The main steps involved:

1.
Define your geographical, temporal and sectoral areas of interest

As the body of literature on climate change is overwhelming (the latest IPCC report contains four volumes with about 3,000 pages) your search should be as focused as possible.

2.
Check literature and online databases; filter out what you need

A list of links to online information sources is provided, with comments, in Annex 2, and you can find a list of important climate change stimuli in Table 2. A general overview of climate change impacts, which might be relevant for your region, can be found in Annex 3.

3.
Consult experts

Most countries have government officials, scientists and consultants working on climate change issues. Annex contains a list of potential institutions and national information sources you could contact for more information.

4.
Consolidate data in a clear and transparent manner

Bring together the information gained in a comprehensible and transparent manner, and make it available to others. A possible format for the compilation is given in Table 3.

Table 3: Possible format for compiling climate change information

Climate Stimulus	Observations	Impacts	Sources
Temperature	1.8 °C increase between1940-2003	first shifts of ecosystems observed (e.g. …)	IPCC 2007 p XXX; ..
	…	…	

Climate Stimulus	Projections	Impacts (direct = physical, indirect = socioeconomic)	Sources
Precipitation	20% decrease by 2050 ….	desertification => losses in food production	XXX et al., 2005; ..
	….	…	

Rapid Literature Assessment	
Strength	**Weaknesses**
good for attaining an initial overview	possibly low credibility for decision makers
cheap and fast	possibly does not address your questions
no experts are needed	unknown quality

Using online data analysis tools

At the time of writing, various online tools are being developed which are intended to help decision makers analyse climate change data.

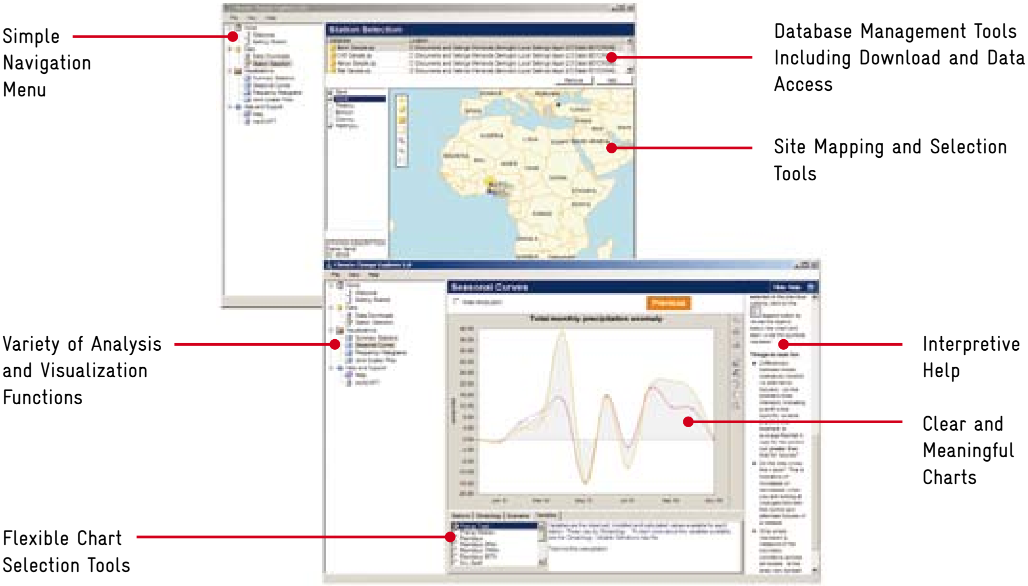
SERVIR

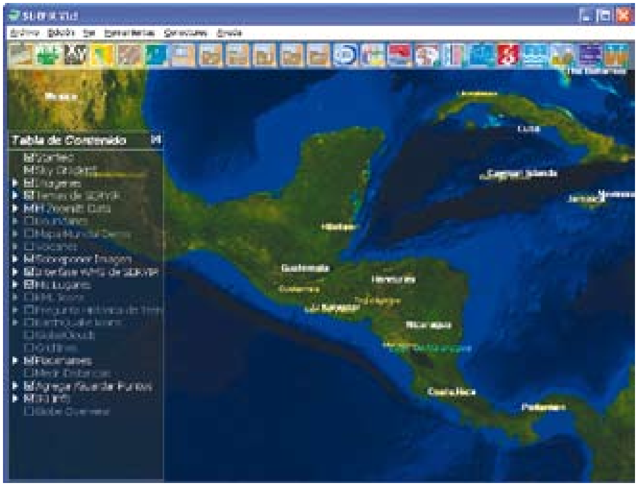
SERVIR is a regional visualisation and monitoring system for Mesoamerica and Africa that integrates satellite and other geospatial data for improved scientific knowledge and decision making by managers, researchers, students and the general public. SERVIR addresses the nine societal benefit areas of the Global Earth Observation System of Systems (GEOSS): disasters, ecosystems, biodiversity, weather, water, climate, oceans, health, agriculture and energy. Here, "climate" covers not only current weather conditions but also climate change projections. For more information: **http://www.servir.net**

Climate Change Explorer

The Climate Change Explorer provides users with an analytical foundation from which to explore the climate variables relevant to their particular adaptation decisions. The approach makes links between understanding vulnerability, monitoring and projecting climate hazards and planning adaptation processes, and is grounded on several key assumptions regarding the interpretation of climate science. The Climate Change Explorer (CCE) is a desktop client that provides an interface for downloading, managing and visualising scaled down model outputs. You will need to apply for a separate password to download a version of this tool. For more information: **http://wikiadapt.org/**

Figure 15: Climate Change Explorer (CCE) developed by SEI, CSAG and AWHERE





SERVIR

developed by a consortium including NASA, CATHALAC, USAID, CCAD, the World Bank, the Nature Conservancy, UNEP-ROLAC and IAGT

World Bank Climate Change Portal

The World Bank Climate Change Portal is intended to provide quick and readily accessible global climate and climate-related data to the development community. The site is based on the Google Maps platform and allows users to access data such as as the outputs from climate models, historical climate observations, natural disaster data, crop yield projections and socioeconomic data at any point on the globe. The site includes a mapping visualisation tool (webGIS) that displays key climate variables, as well as linkages to World Bank databases and a spatially-referenced knowledge base. For more information: **http://sdwebx.worldbank.org/climateportal/**"

Climate Impacts: Global and Regional Adaptation Support Platform (CI:grasp)

Funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), PIK and GTZ are in the process of developing a global and regional adaptation support platform.This is an interactive online database with different information layers. It will provide information on climate stimuli, different impacts and adaptation information. For more information: **www.ci-grasp.org**

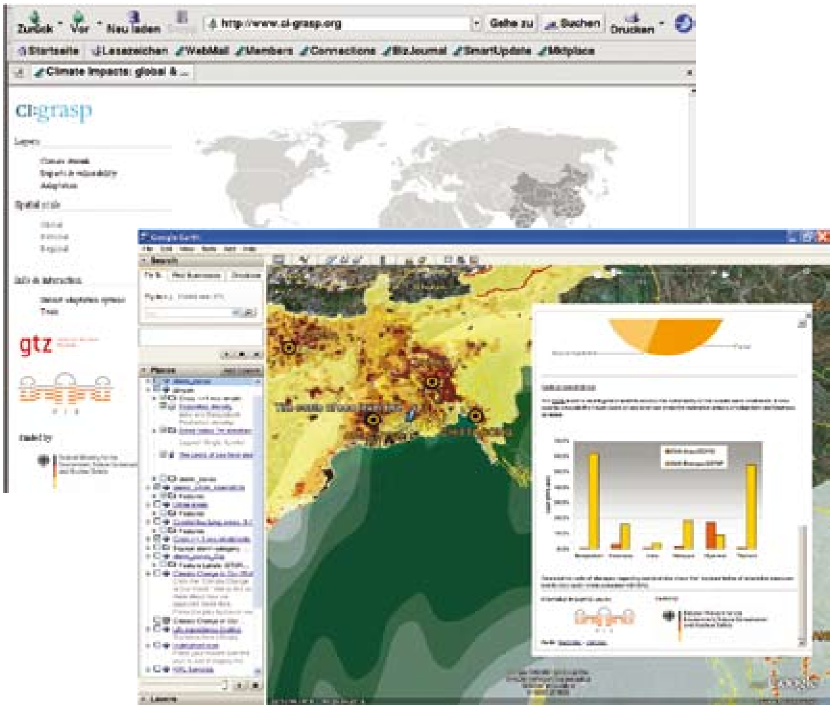
Using online data analysis tools

Strengths	good for attaining an initial overview	fast	cheap	no experts needed
Weaknesses	may be misleading to manage adaptation from the desktop	provides only isolated views	fast internet connection necessary	provides analytical support

Figure 16:

Climate Change Portal (including the tool ADAPT)

developed by the World Bank



Climate Impacts: Global and Regional Adaptation Support Platform (CI:grasp)

Three interactive information layers: climate stimuli, impacts & vulnerabilities and adaptation options & experiences.

developed by PIK and GTZ

Comprehensive assessment using climate change expertise

If you cannot find the necessary climate change information for your needs, you might consider commissioning your own tailored research. This might involve asking a scientific institution such as PIK to run an RCM for your region, or applying impact, vulnerability and adaptation assessments. This kind of research is a rapidly developing field, with a large number of research groups applying many different models. Only a preliminary overview of all this work is available so far[9]; nearly all of it is taking place in the scientific arena and only a few (international) consultancies are engaged in it. To identify such institutions, see Annex 4 and contact the climate change experts in your country.

The costs of such assessments can vary a lot. If RCM already exist in your region, scientific institutions normally provide them free of charge. If new model runs are necessary this can take months or even years, and can cost a five or six digit figure. Thanks to several research projects, the number of RCM for developing countries is increasing. You can find a selection of well-known RCM in Annex 5.

② Interpreting climate change information and dealing with uncertainty

Climate change information has to be interpreted for any individual context. Here are some principles or rules of thumb to help you do this.

General rules

- Use information about historic climate variability and change (especially extreme events), as well as adaptation experiences as a starting point.

- Adaptation is a social and institutional learning process. Bring together different stakeholders (decision

---

[10] *http://unfccc.int/adaptation/nairobi_workprogramme/compendium_on_methods_tools/items/2674.php*

makers, scientists, model developers, target groups, sector specialists etc.) to discuss the climate change information you have gathered, and its implications.

- Try to gather different regional scenarios.

- Support climate change impact research in order to increase the knowledge base.

- Compile the relevant information you have been able to obtain, and make it available to others. One of the main challenges will be the management of uncertainty. The following suggestions might help:

Uncertainty and data interpretation

- Differentiate between uncertainties of models and of the emission scenarios (unknown development pathway of humankind).

- Do not assume that uncertainty means there will be no change. One of the most improbable options is that nothing will change.

- There will always be an inherent, irresolvable uncertainty involved in climate change projections. A paradigm shift is needed. Uncertainty must be managed not overcome by decision makers.

- The levels of uncertainty differ with regard to geographic area, time and climate variable (e.g. there is normally less uncertainty about temperature than precipitation). Try to define both the origin of climate change information for your region (scenario, models, impact assessments) and the level of uncertainty involved.

- Some scientific studies (including those by the IPCC) rate the level of confidence in, and likelihood of their statements—make use of this information.[10]

- Rather than using a single model, try to use "possibility ranges".

- Be sure to evaluate the plausibility of all top-down information you acquire and add to it with complementary information from climate experts, (sector) experts and stakeholders at the local level (bottom-up).

Uncertainty and identification of adaptation measures

- Be aware that adaptation to climate change is not the only area of planning affected by uncertainty.

- Try to find "no regret" or "low regret" adaptation activities (ideally a "win-win-win" situation for mitigation, adaptation and sustainability).

- Try to identify flexible and reversible options.

- Where there is just a low level of uncertainty, concentrate on tangible impacts (e.g. countermeasures against glacier lake outburst). When facing more uncertainty, try to increase adaptive capacities (e.g. higher efficiency of water usage during the threat of a possible drought).

- Use analogies by identifying regions with similar cli-

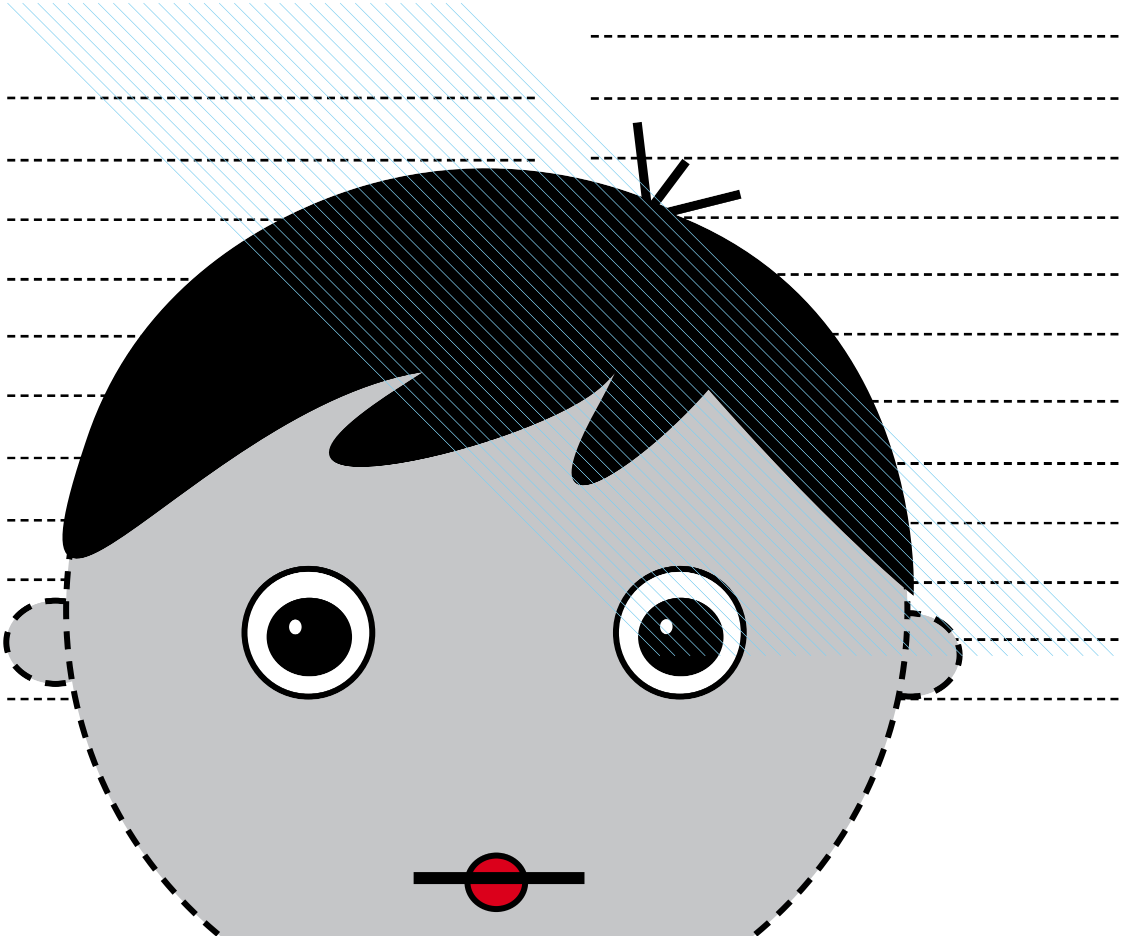
---

[11] *http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-uncertainty-guidancenote.pdf*

matic conditions to those predicted for your region, or learn from past events in your region (see 3.2.5).

● Try to apply "adaptive management"—an iterative learning process (learning to manage by managing to learn) through which you continuously improve your knowledge of climate change impacts.

● Take into account the time dimension of impacts. When are the impacts expected? Is action necessary today?



③ Communicating climate change information

When communicating climate change information to others you bear a great responsibility. If decision makers base their adaptation decisions on information from you which turns out to be wrong, not only does this damage your credibility, it might also—more seriously—cause inappropriate adaptation or bad investments.

In discussing climate change it is easy to become alarmist. Decision makers might be more readily convinced if one exaggerates things than when facing differentiated presentations. You should avoid falling into this trap. Obviously the information you provide depends very much on the recipient. You would approach a decision maker with just 10 minutes' time in a different way than you would address stakeholders at a daylong workshop. Nevertheless, there are certain rules you should take into account when you communicate climate change information to others:

- Avoid alarmism – base your statements on sound scientific findings.
- Stress the importance both of interpreting climate change and of managing uncertainty—use "possibility ranges" (several plausible and reasonable futures: that is the most important lesson for every decision maker to learn).
- Provide a background of basic climate change science to help decision makers interpret the information (as presented in Part I).
- Be transparent and precise (and when discussing uncertainty, make it clear what the major sources of uncertainty are—the emission scenarios rather than the models!).
- Be exact about timescales (a sea level rise of one metre by 2100 or by 2030 makes a big difference).
- Get support from experts, as they can answer more critical questions and thereby increase credibility.
- Be aware of the conflict you are in: on the one hand you might be aware of your own uncertainty and pos-

sess inadequate knowledge; on the other hand you want to convince people.

- Try to use neutral language and avoid value-laden statements.

A common argument in bar-room politics and from armchair strategists is that climate change is the biggest hoax ever. Although this contention has been absolutely disproved by unequivocal scientific findings, you might still find yourself confronted with such arguments. The Royal Society has written a simple guide discussing the most frequent misleading arguments against climate change, which might help you to address them[11].

Probability and climate change

Decision makers often ask for the probability of a future scenario. Climate change scenarios cannot be associated with the notion of probability as they are hypothetical futures based on hypothetical storylines about humankind's behaviour for the next 100 years. Probability is a statistical concept based on the frequency of events. These are not available for scenarios. Nevertheless based on our physical understanding and using certain assumptions about the development path humans will take, we can say how things are likely to progress in the future.

---

[12] *http://royalsociety.org/trackdoc.asp?id=4085&pId=6229*

Annex 1: Storylines for the emission scenarios

A 1

- Rapid economic growth
- A global population that reaches nine billion in 2050 and then gradually declines
- The quick spread of new and efficient technologies
- A convergent world - income and way of life converge between regions. Extensive social and cultural interactions worldwide

There are subsets to the A1 family based on their technological emphasis:

1. **A1FI** - An emphasis on fossil fuels
2. **A1B** - A balanced emphasis on all energy sources
3. **A1T** - Emphasis on non-fossil energy sources

A 2

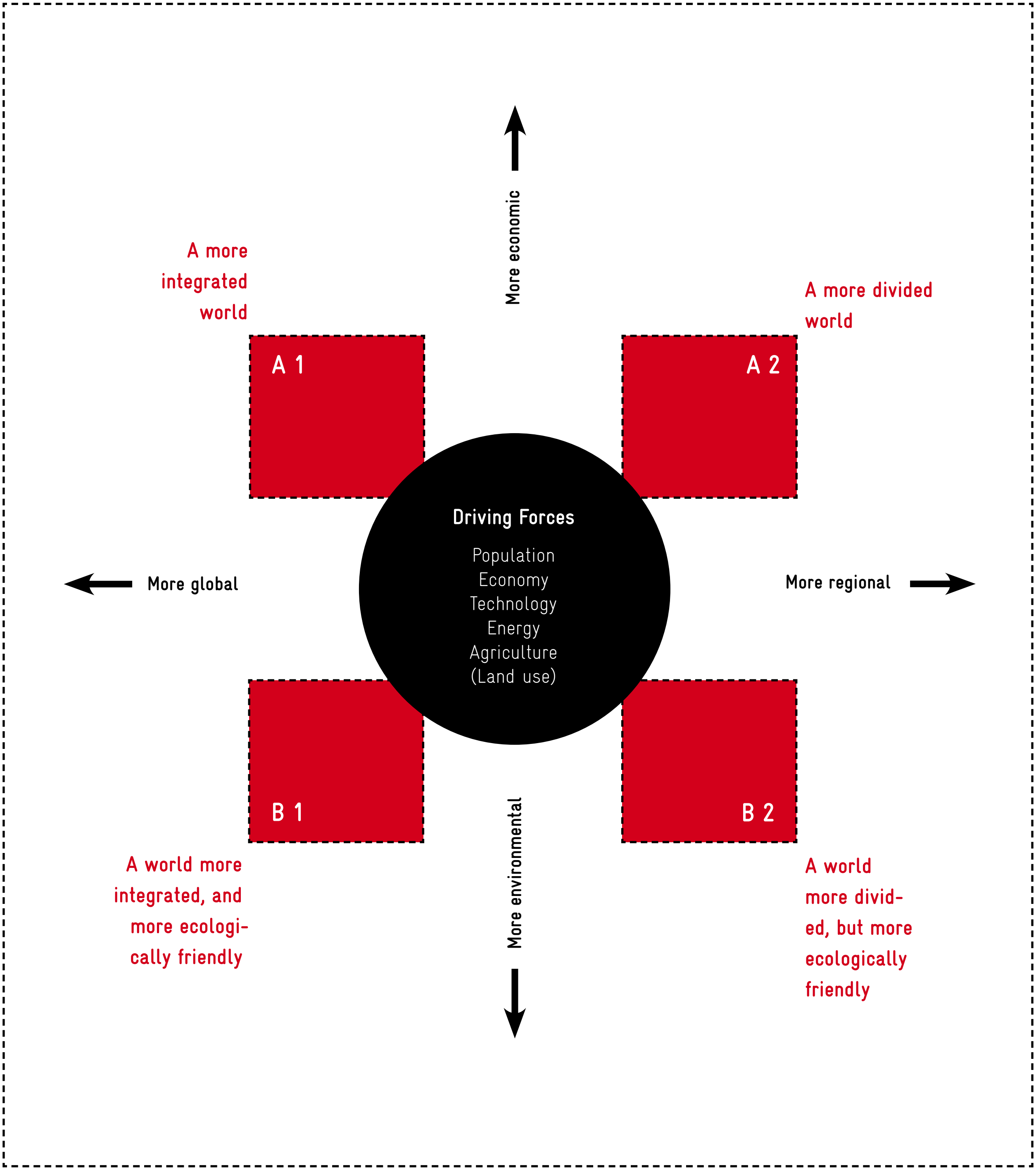
- A world of independently operating, self-reliant nations
- Continuously increasing population
- Regionally-oriented economic development
- Slower and more fragmented technological changes and improvements to per capita income

B 1

- Rapid economic growth as in A1, but with rapid changes towards a service and information economy
- Population rising to 9 billion in 2050 and then declining as in A1
- Reductions in material intensity and the introduction of clean and resource-efficient technologies
- An emphasis on global solutions to economic, social and environmental stability

B 2

- Continuously increasing population, but at a slower rate than in A2
- Emphasis on local rather than global solutions to economic, social and environmental stability
- Intermediate levels of economic development
- Less rapid and more fragmented technological change than in B1 and A1


A more integrated world
More economic
A more divided world
A 1
A 2
Driving Forces
Population
Economy
Technology
Energy
Agriculture
(Land use)
More global
More regional
B 1
B 2
More environmental
A world more integrated, and more ecologically friendly
A world more divided, but more ecologically friendly

Annex 2: List of links to online information sources, with comments

The list below is a selection of the more important internet sources. For a comprehensive link list, go to **www.gtz.de/climate** (online soon).

Essential information sources

IPCC

The Fourth Assessment Report (AR4) contains reports of three working groups (WGs) and a synthesis report under the following link: **http://www.ipcc.ch/ipccreports/assessments-reports.htm**

Regional climate change projections

Source: Chapter 11 Regional Climate Projections, WGI, (12 MB, 5-10 pages per continent)

Assessments of impacts and vulnerabilities for each continent

Source: Working Group II: Chapter 9: Africa (2 MB, 36 pages) Chapter 10: Asia (1 MB, 38 pages) Chapter 13: Latin America (1 MB, 37 pages)

National Communications to the UNFCCC

Under the UNFCCC, developing countries are obliged to submit so-called National Communications. These normally include information on climate change impacts and adaptations in the particular national contexts. Most countries have published at least one National Communication.

http://unfccc.int/national_reports/non-annex_i_natcom/items/2979.php

National Adaptation Programmes of Action

NAPAs (national adaptation programmes of action) provide a process for Least Developed Countries (LDCs) (and only for them) to identify priority activities that respond to their urgent and immediate needs with regard to adaptation to climate change. They normally include information on climate change impacts and possible adaptation measures.

http://unfccc.int/cooperation_support/least_developed_countries_portal/submitted_napas/items/4585.php

Additional sources of information

Adaptation country profiles

Country profiles on adaptation with an overview of key climate change figures, provided by UNDP

http://country-profiles.geog.ox.ac.uk/
http://www.adaptationlearning.net/profiles/

World Bank Climate Portal

The World Bank Climate Portal provides a rich variety of country specific climate change information.

http://sdwebx.worldbank.org/climateportal/

Impact maps of climate change

A selection of world maps showing impacts of climate change, provided by UNDP

http://www.undp.org/gef/adaptation/climate_change/02a.htm

WBGU

In-depth scientific explorations of the overarching themes of global change and recommendations for action and research.

http://www.wbgu.de/wbgu_publications.html

AIACC

Assessments of Impacts and Adaptations to Climate Change (AIACC) in Multiple Regions and Sectors provide rich climate change data for 24 countries

http://www.aiaccproject.org
http://sedac.ciesin.columbia.edu/aiacc/

Information sources on natural disasters

CRED/OFDA International Disaster Database

The EMDAT database provides global disaster statistics, including country-level disaster profiles.

http://www.em-dat.net/

Disaster Risk Index

A country-by-country tool to assess disaster risk, developed by UNEP's Global Resource

http://gridca.grid.unep.ch/undp/

Natural Disaster Hotspots: A Global Risk Analysis

A worldwide assessment of natural disasters by the Centre for Hazards and Risk Research at Columbia University

http://www.ldeo.columbia.edu/chrr/research/hotspots/

PreView

Another UNEP tool for visualising natural disaster data in more detail

http://www.grid.unep.ch/activities/earlywarning/preview/

Reliefweb

A country-by-country database of emergency appeals, maintained by UNOCHA (United Nations Office for the Coordination of Humanitarian Affairs)

http://www.reliefweb.int

Annex 3: Selected climate change impacts

Phenomenon and direction of trend	**Likelihood that trend occurred in late 20th century**	**Likelihood of future trend**	**Examples of major impacts**
Over most land areas, warmer days and nights; fewer cold, and more frequent hot days and nights	Very likely	Virtually certain	Increased agricultural yields in colder environments, decreased yield in warmer environments Increased insect outbreaks Effects on water resources relying on snow melt Reduced mortality from cold exposure Declining air quality in cities
Over most land areas, more frequent warm spells and heat waves	Very likely	Very likely	Reduced yields in warmer regions due to heat stress Increased risk of bushfires Increased water demand, water-quality problems Increased heat-related mortality, particularly for the elderly, chronically sick, very young and socially isolated

Phenomenon and direction of trend	**Likelihood that trend occurred in late 20th century**	**Likelihood of future trend**	**Examples of major impacts**
Over most areas, increasing frequency of heavy precipitation	Likely	Very likely	Damage to crops Soil erosion Adverse effects on quality of surface and ground water Water scarcity may be relieved Increased risk of deaths, injuries, and infectious, respiratory and skin diseases Disruption of settlements, commerce, transport and societies due to flooding Pressures on urban and rural infrastructure Loss of property
Increasing area affected by drought	Likely in many regions since 1970s	Likely	Land degradation Lower yields, crop damage Increased livestock deaths Increased risk of wildfire Increased risk of food and water shortage Increased risk of malnutrition Increased risk of water and food-borne diseases Migration

Phenomenon and direction of trend	Likelihood that trend occurred in late 20th century	Likelihood of future trend	Examples of major impacts
Increasing intensity of tropical cyclones	Likely in some regions since 1970s	Likely	Damage to crops and trees Power outages causing disruptions to public water supplies Increased risk of deaths, injuries and disease spread through water or food Post-traumatic stress disorder Disruptions due to flooding and high winds Withdrawal by private insurers of risk coverage in vulnerable areas Migration, loss of property
Increased incidence of extremely high sea levels	Likely	Likely	Salinisation of irrigation water and freshwater systems, and decreased availability of freshwater Increased risk of deaths and injuries by drowning in floods Migration-related health effects Costs of coastal protection versus relocation Potential for relocation of people and infrastructure Tropical cyclone effects.

Source: IPCC (2007b)

Annex 4: Potential institutions and national information sources

Potential institutions and experts with expertise in specific national contexts

- Relevant ministries and government agencies
- UNFCCC focal points[12]
- UNFCCC expert roster[13]
- Meteorological services and institutes
- Universities
- Donor agencies
- Scientific or development NGOs
- Authors of NATCOMs

Possible national information sources

- National Communications[14]
- Inventories, maps and data series of natural events and climate-related risks (e.g. drought, flooding)
- National reports on desertification
- Disaster preparedness plans, inventories and reviews
- Sectoral analyses (e.g. agriculture, water resources, energy)
- Local vulnerability studies
- Environmental goods and services assessments
- Inventories, maps and data series on climate risks (e.g. drought, flooding) or relevant socioeconomic patterns
- Regional climate change scenarios
- Poverty Reduction Strategy Papers (PRSPs)
- Food security plans

[13] *http://maindb.unfccc.int/public/nfp.pl#beg*
[14] *http://maindb.unfccc.int/public/roe/*
[15] *http://unfccc.int/national_reports/non-annex_i_natcom/items/2979.php*

Annex 5: A selection of well-known RCM:

Regional Climate Model	**Developer**	**Comment/Model type**
CCRM	Canadian Regional Climate Model, Canada	Dynamic
COAMPS	Marine Meteorology Division of the Naval Research Laboratory (NRL), USA	Dynamic, free of charge http://www.nrlmry.navy.mil/coamps-web/web/home
CCLM	Climate Limited Area Modelling Community, (Lead: German Weather Services (DWD)), Germany	Dynamic, also known as COSMO-CLM
DARLAM	Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia	Dynamic
NRCM	National Center for Atmospheric Research (NCAR), USA	Dynamic
HADRM3	Hadley Centre, United Kingdom	Dynamic

Regional Climate Model	**Developer**	**Comment/Model type**
HIRHAM	Danish Meteorological Service (DMI), Max Planck Institute for Meteorology, Denmark/Germany	Dynamic
PRECIS	Hadley Centre, UK Met Office, United Kingdom	Dynamic, free of charge for developing countries http://precis.metoffice.com/
RACMO2	Netherlands Weather Service (KMNI), Netherlands	Dynamic
RegCM3	International Centre of Theoretical Physics (ICTP), Italy	Dynamic, free of charge http://users.ictp.it/~pubregcm/RegCM3/
REMO	Max Planck Institute for Meteorology, Germany	Dynamic
RCA3	Rossby Centre (SMHI), Sweden	Dynamic
STAR	Potsdam Institute for Climate Impact Research (PIK), Germany	Statistical
WETTREG	Climate and Environment Consulting Potsdam (CEC), Germany	Statistical

DEFRA (2009): Climate Change Scenarios for India, access May 13rd, 2009 http://www.defra.gov.uk/environment/climatechange/internat/devcountry/pdf/india-climate-2-climate.pdf

IPCC (2000): Special Report on Emissions Scenarios, edited by N. Nakicenovic and R. Swart, Intergovernmental Panel on Climate Change Cambridge (IPCC): Cambridge University Press, UK.

IPCC (2007a): Climate change 2007: The Physical Science Basis. Report of the Working Group I of the Intergovernmental Panel on Climate Change (IPCC), edited by S. Solomon, D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller, Cambridge: Cambridge University Press, UK.

IPCC (2007b): Climate Change 2007: Impacts, Adaptation and Vulnerability. Report of the Working Group II of the Intergovernmental Panel on Climate Change (IPCC); edited by M. L. Parry, O. F. Canziani, J. P. Palutikof, P. J. van der Linden and C. E. Hanson, Cambridge University Press, Cambridge, UK.

Jones, R.G. et al. (2004): Generating high resolution climate change scenarios using PRECIS, Met Office Hadley Centre, Exeter, UK, 40pp.

Lüdeke, M.K.B. et al. (1999): Rural poverty driven soil degradation under climate change: the sensitivity of disposition towards the Sahel syndrome with respect to climate. Environmental Modeling and Assessment 4(4): 295-314.

Meinshausen, M. (2007): Page 49 in: Human Development 2007/2008, Fighting Climate Change: Human Solidarity in a divided world. United Nations Development Programme, New York. USA.

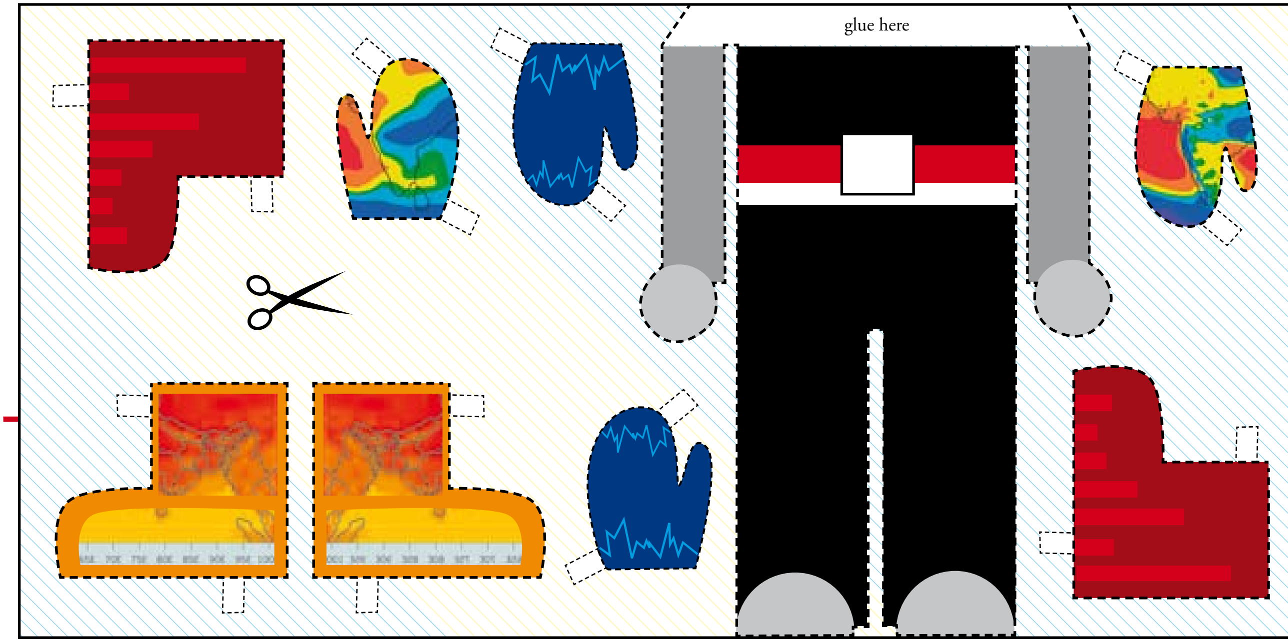
O'Brien, K. et al. (2004): Mapping vulnerability to multiple stressors: climate change and globalization in India, Global Environmental Change 14: 303–313.

Raupach, M.R. et al. (2007): Global and regional drivers of accelerating CO2 emissions. PNAS 104 (24): 10288-10293.

Schellnhuber, H.J. et al. (1997): Syndromes of Global Change. GAIA 6(1): 19-34.

Schipper, L. (2007): Climate Change Adaptation and Development: Exploring the Linkages, Tyndall Centre for Climate Change Research Working Paper 107, Norwich, UK.

Stott, P. A. et al. (2004): Human contribution to the European heatwave of 2003. Nature 432: 610-613.



Deutsche Gesellschaft für
Technische Zusammenarbeit (GTZ) GmbH

- German Technical Cooperation -

Climate Protection Programme

Dag-Hammarskjöld-Weg 1-5
65760 Eschborn/Germany
T +49 61 96 79-0
F +49 61 96 79-11 15
E info@gtz.de
I www.gtz.de