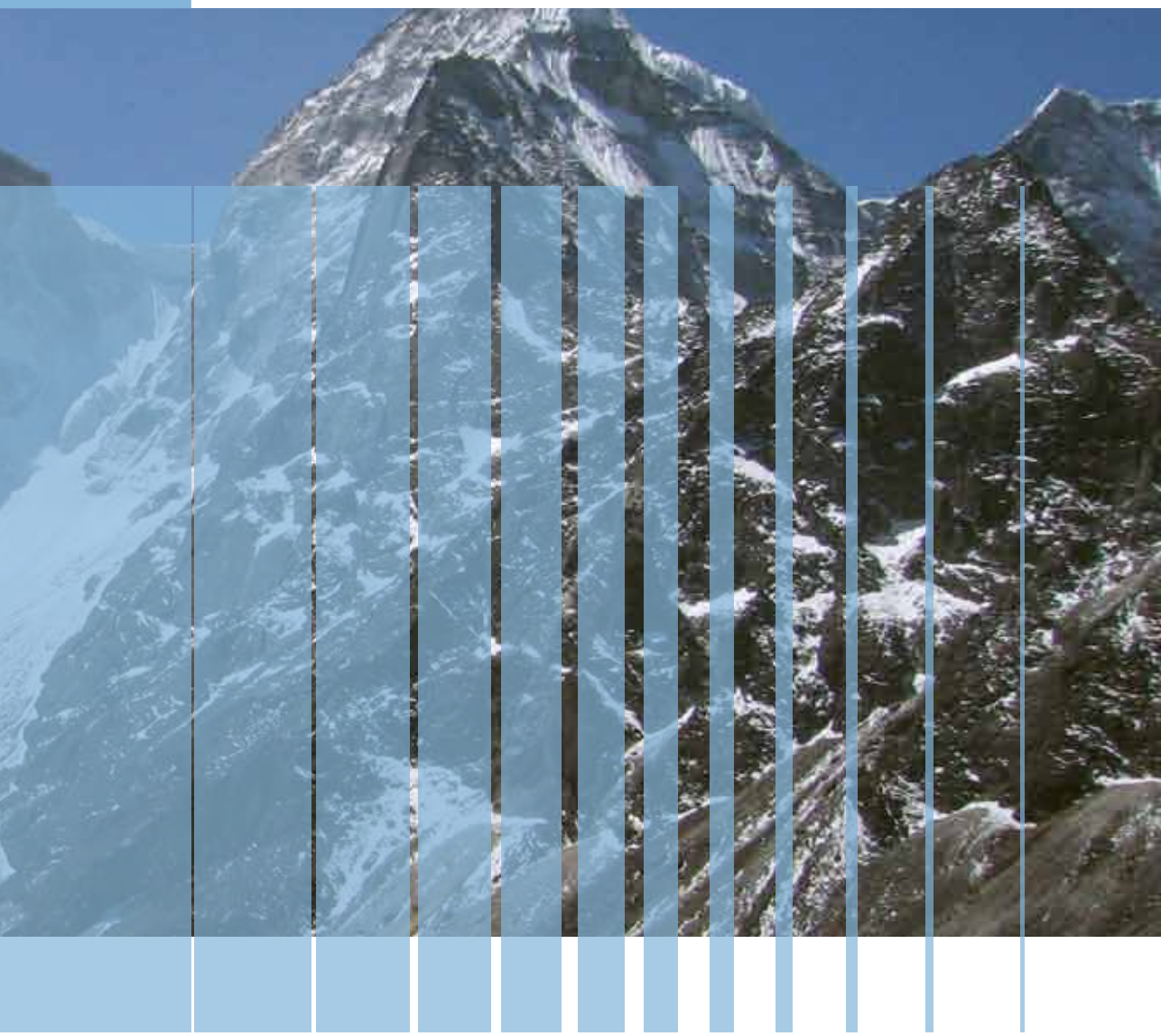
Assessing an IPCC assessment

An analysis of statements on projected regional impacts in the 2007 report



Netherlands Environmental Assessment Agency

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The Netherlands Environmental Assessment Agency (PBL) is the national institute for strategic policy analysis in the field of environment, nature and spatial planning. We contribute to improving the quality of political and administrative decision-making by conducting outlook studies, analyses and evaluations in which an integrated approach is considered paramount. Policy relevance is the prime concern in all our studies. We conduct solicited and unsolicited research that is both independent and always scientifically sound.

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Foreword

In January 2010, the media reported two errors in specific parts of the Fourth Assessment Report of 2007 by the *Intergovernmental Panel on Climate Change* (IPCC). The media reports gave rise to questions about the credibility of the overall IPCC assessment: could politics and society still rely on the IPCC for an assessment of the scientific knowledge on climate change?

On 28 January 2010, the Dutch Parliament asked Jacqueline Cramer, the then Dutch Minister for the Environment, for an investigation into the implications of these errors in the IPCC report. Minister Cramer subsequently requested the Netherlands Environmental Assessment Agency (PBL)[1] to make an assessment of the reliability of the regional chapters (9 to 16) of the IPCC Working Group II contribution to the Fourth Assessment Report (the part on Impacts, Adaptation and Vulnerability), and to assess the effects of any errors on the summary conclusions drawn by the IPCC.

From the outset it was clear that the PBL would not be able to repeat the original IPCC Working Group II assessment, given the sheer volume of the scientific work reported in the IPCC exercise.[2] What we were able to do, however, was investigate the extent to which the IPCC in their summaries had presented existing scientific knowledge to the world of policymakers, in a way that was supported by the underlying texts and scientific references. What is more, we also investigated what could be learned from our findings so that informed choices can be made in future assessments. This seemed the more reasonable approach, as behind the request from the Dutch Parliament was a more general concern: could policymakers and the public at large still trust the IPCC's key messages?

A scientific assessment – an analysis and weighing of the actual scientific knowledge – of a complex problem such as climate change is a tremendously difficult task. The IPCC is a bridge between science and policy: a so-called 'science–policy interface'. The IPCC is not conducting science, nor is it making policy, but should provide the guarantee that policymakers can come to their decisions on the basis of the best available knowledge regarding climate change. We have

1) The Netherlands Environmental Assessment Agency (PBL) is an independent governmental body that by statute provides the Dutch Government and Parliament – and the European Commission, European Parliament and UN organisations – with scientific advice on problems regarding the environment, sustainability and spatial planning. PBL authors have contributed to several assessments of the IPCC. During the Third and Fourth Assessments, the PBL hosted the Co-Chair and Technical Support Unit of Working Group III (Mitigation on Climate Change).

2) Elsewhere we have reported on new insights into climate science since the Fourth Assessment Report (cf. *News in Climate Science and Exploring Boundaries*, 2009).

investigated how this task was taken on by the IPCC Working Group II in their assessment of the regional impacts of climate change. Based on this investigation we have formulated some recommendations to further improve the quality of these assessments.

The investigation was conducted realising that climate science and policymaking are currently taking place in a new era, characterised by a high degree of politicisation, a much more dynamic interaction between science and public discourse, and vocal citizens who either want to know whether policy measures under discussion are all really necessary, or who are of the opinion that suggested measures do not go far enough. This new context comes with new requirements for the IPCC assessments. Our suggestions are thus not always meant as criticism of the 'architecture' of the climate report of Working Group II as this was being drawn up in the years leading up to its publication in 2007. Yet we believe that, by being critical and self-critical of work contained in the Fourth Assessment Report, we can contribute to further improving the reliability of future IPCC reports. It is an exercise in future-oriented learning.

Accomplishing our task would have been impossible without the cooperation of the IPCC authors of Working Group II, who were willing to devote a considerable amount of their time to answering our questions, and did so within the strict time tables we had set them. It is clear that the responsibility for the research, as well as for the presentation of the findings, the conclusions drawn, and the recommendations made, lies solely with the Netherlands Environmental Assessment Agency (PBL).

Our investigation is focused in character and size. However, a number of conclusions and recommendations concern the set up of the procedures and processes of the IPCC. Hopefully, those suggestions can still play a role in the review by the InterAcademy Council, that will become available by late August 2010, focusing on procedural and process issues of the IPCC.[3)]

Professor Maarten Hajer
Director, Netherlands Environmental Assessment Agency (PBL)

3) InterAcademy Council 2010, *Review of the IPCC; an evaluation of the procedures and process of the Intergovernmental Panel on Climate Change,* http://reviewipcc.interacademycouncil.net/index.html

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Executive summary

The Netherlands Environmental Assessment Agency (PBL) has investigated the scientific foundations for the IPCC summary conclusions of the Fourth Assessment Report of 2007 on projected regional climate-change impacts, at the request of the Dutch Minister for the Environment. Overall the summary conclusions are considered well founded and none were found to contain any significant errors. The Working Group II contribution to the Fourth Assessment Report shows ample observational evidence of regional climate-change impacts, which have been projected to pose substantial risks to most parts of the world, under increasing temperatures. However, in some instances the foundations for the summary statements should have been made more transparent. While acknowledging the essential role of expert judgment in scientific assessments, the PBL recommends to improve the transparency of these judgments in future IPCC reports. In addition, the investigated summary conclusions tend to single out the most important negative impacts of climate change. Although this approach was agreed to by the IPCC governments for the Fourth Assessment Report, the PBL recommends that the full spectrum of regional impacts is summarised for the Fifth Assessment Report, including the uncertainties. The PBL believes that the IPCC should invest more in quality control in order to prevent mistakes and shortcomings, to the extent possible.

No significant errors found in summary conclusions

The foundations for thirty-two IPCC Fourth Assessment summary conclusions on the regional impacts of climate change have been investigated. These conclusions show examples of projections of climate-change impacts on food, water, ecosystems, coastal regions and health, for all the earth's continents. These conclusions have not been undermined by errors, although one of the conclusions contains a minor inaccuracy: in hindsight, not 75 to 250 million people, but 90 to 220 million people are projected to be exposed to increased water stress due to climate change in Africa, by 2020. Given the large uncertainties surrounding such projections, this difference is not significant.

Provenance of summary statements needs to become more transparent in future reports

Seven of the investigated 32 conclusions on the regional impacts of climate change contain information that we were unable to sufficiently trace to the underlying chapters in the IPCC Working Group II Report or to the references therein. For two of these conclusions, our critical comments pertain to insufficiently founded generalisations from existing scientific research, in both cases from local to regional scales, and for one of them also from one type of livestock to livestock in general. The PBL recommends to invest in the improvement and transparency of the foundations of summary conclusions in future IPCC reports.

The regional chapters: one significant error and some comments

In the underlying regional chapters, in addition to the two already known errors about the melting of the Himalayan glaciers and about the Dutch land area below sea level, another significant error was found: a 50 to 60% decrease in productivity in anchovy fisheries on the African west coast was projected on the basis of an erroneous interpretation of the literature references. It appeared to be about a 50 to 60% decrease in extreme wind and seawater turbulence, with some effects on the anchovy population that were not quantified. We found certain inaccuracies, ranging from (very) small errors in numbers to imprecise literature references. In addition, the PBL has some critical comments to make. One of these relates to the fact that the report does not specify how many of the additional heat-related deaths projected for Australian cities are actually attributable to climate change – a sizeable fraction is due to demographic changes alone. However, these shortcomings do not affect the investigated 32 summary conclusions or other parts of the IPCC summaries.

Examples of negative impacts dominate at summary level

The IPCC Working Group II Report focuses on climate impacts, adaptation and vulnerability. It was found that, in the IPCC's highest level summary, the conclusions that were derived from the regional chapters of the Working Group II contribution to the Fourth Assessment Report single out examples of projections of *negative* climate-change impacts. The IPCC authors considered these to be the most relevant to policymakers. The PBL has labelled this as a 'risk-oriented' approach, which had been implicitly endorsed by the governments that constitute the IPCC (including that of the Netherlands). The PBL subscribes to the importance of an approach that highlights what may go wrong under unmitigated climate change, but the Working Group II Report lacked a clear explanation of the choice of approach and its consequences. Alternatively, it could be argued that policymakers should be presented with a complete picture in the Summaries for Policymakers, not just with negative examples (without suggesting that potential positive effects cancel out potential negative effects). We recommend that, for the Fifth Assessment Report, the choice of the approach taken is made explicit. Moreover, we suggest that, at Summary for Policymakers level, two separate sections are included dealing with projected regional impacts on water, food, ecosystems, coastal regions and health:

- One section that describes the projected full range of climate-change impacts, including uncertainties, positive impacts, and the relative contributions from other important areas, such as industrialisation, population growth, and land use;
- One section that describes the most important negative impacts, including a worst-case risk approach, based on a clearly explicated risk-assessment methodology.

No consequences for overarching conclusions

Our findings do not contradict the main conclusions of the IPCC on impacts, adaptation and vulnerability related to climate change. There is ample observational evidence of natural systems being influenced by climate change on regional levels. The negative impacts under unmitigated climate change in the future pose substantial risks to most parts of the world, with risks increasing at higher global average temperatures.

Other recommendations

Additional recommendations for future IPCC publications include:

- Create a public website for the submission of possible errors found in the published reports;
- Provide stronger underpinning of generalisations of case studies to entire regions or sectors, also making use of regional modelling studies;
- Ensure that statements that attribute impacts to climate change are well founded in scientific research, including systematic observations, modelling and statistics. The climate change component of impacts should be carefully characterised.
- Be careful with phrasing of statements that could be perceived by readers as heightening the projected impacts of climate change;
- IPCC governments should provide financial support for hiring chapter assistants to assist with quality control;
- Assure that the reviews of all draft texts are fully covered by several expert reviewers;
- Strengthen the expert and government reviews of the foundation for and provenance of statements in the summaries;
- IPCC governments should increase their investments in climate-change observations and modelling in developing countries.

The Dutch Parliament resolution and the subsequent assignment given to the PBL

In January 2010, worldwide media attention was given to two errors that were discovered in a part of the Fourth Assessment Report of the IPCC of 2007: an erroneously high rate of melting of the Himalayan glaciers, and an erroneously high percentage of land area in the Netherlands lying below sea level. The commotion in the Dutch media and the subsequent discussion at the political level in the Netherlands led to a resolution by the Dutch Parliament on 28 January 2010, which declared in the preamble that the reliability of the IPCC should be undisputed but was now at issue. In the resolution, the parliament required that the government would instruct the Netherlands Environmental Assessment Agency (PBL) to provide a new update on climate science, including the implications of the said errors.

Based on this resolution and the debate in parliament, the Minister for the Environment decided to limit her question to PBL to an investigation in the implications of possible errors in the regional chapters of the IPCC report of 2007 on climate-change impacts, adaptation and vulnerability, paying specific attention to the Himalayan glaciers.

Specification of the assignment

The PBL, subsequently, broadened the assignment somewhat by including an investigation of the conclusions on regional impacts, as described in the highest summary level of the combined IPCC 2007 reports (the 'Synthesis Report'). In addition, the investigation report would also include annexes on the Himalayan glaciers, on the percentage of land area in the Netherlands lying below sea level, and on the protection of the Netherlands against sea level rise. The last annex was added, since the errors about the Himalayan glacier melting and about the percentage of Dutch land area below sea level had triggered a political discussion on whether Dutch policies dealing with sea level rise would need to be revised.

For the 'update on climate science', as requested by the Dutch Parliament, we refer to a PBL study 'News in Climate Science and Exploring the Boundaries' (December, 2009). That report, drawn up together with the Royal Netherlands Meteorological Institute (KNMI) and Wageningen University and Research Centre (WUR), revisited the IPCC conclusion that global warming since the middle of the 20th century is very likely to have been due to human influence on the global climate. This statement was found to be robust, even when taking into account peer-reviewed scientific literature expressing doubts on this relation. We took this and other findings of the Working Group I as a point of departure for our investigation into the IPCC statements on the projected regional impacts of climate change.[1)]

Given the constraints regarding time and capacity, it was not possible for the PBL to check a hundred per cent of all texts and references in the eight regional chapters of the Working Group II Report for errors, considering that it had taken hundreds of authors and reviewers to produce the report over the course of five years. Instead, we limited ourselves to the IPCC summary statements, and framed the central questions of this report as follows:

Are the summary conclusions on regional impacts well founded on the underlying chapters and literature references? Are there errors in statements that have travelled from the scientific literature references and/or the main texts through to the summary conclusions? If errors are found, do they affect the validity of these conclusions? What recommendations can we derive from our investigation in order to further improve the quality of the assessment process for the Fifth Assessment Report (due in 2014)?

The role of IPCC assessments and the role of the PBL

Policymakers need to be well informed about the state of the art in climate science. Obtaining a reliable overview of the scientific literature, with its many different and sometimes contradicting messages, is something policymakers can obviously not achieve on their own. What is more, a knowledge base that is shared and accepted as credible and legitimate by all parties involved, can be of great value to the policy process. Therefore, in 1989, the UN member governments that constitute the IPCC arranged a process in which worldwide groups of carefully selected expert authors, periodically, would assess the ever growing amounts of scientific literature on climate. Working within the confines of the IPCC, authors arrive at collective judgments that are supposed to present the state of the art in climate science, in a comprehensive, unbiased, non-policy-prescriptive way. The strict procedures established by the IPCC member governments are to guarantee precisely this. The credibility of an IPCC report depends both on the knowledge and integrity of the author teams and on the thoroughness and expertise of expert and government reviewers.

The PBL generally has an intermediate role in interpreting IPCC reports, so that these can be applied in policy-making by the Dutch Government and Parliament. In this case, the PBL has had to assess the reliability of some key messages derived from a particular IPCC report; the Working Group II Report. To this end, we needed

1) There is a forthcoming publication by the Royal Netherlands Academy of Sciences (KNAW) that will examine this fundamental part of climate science in more detail.

to rely on the expert judgments of IPCC authors, to some extent, as it would have been impossible to track down and assess all theory, measurements, observations, model calculations, and all arguments that the IPCC authors may have used during the five-year assessment period in order to arrive at certain conclusions. However, we could investigate whether the key messages in the summary were being backed up by material discussed in the main chapters of the IPCC assessments, whether relevant information in the main chapters, in our opinion, had been founded on sound scientific sources, and whether there would be any obvious errors or mistakes in the (presentation of) the material investigated.

IPCC assessments are always snapshots in time – representative of the knowledge of science as it is at that moment. As science proceeds, insights may change. However, in our investigation, we have not included new scientific information that has become available since the Fourth Assessment Report was produced – our task was not to redo the IPCC assessment, but to investigate its underpinning at the time of finalisation, in early 2007.

Focus of the investigation

The 2007 Fourth Assessment Report of the IPCC contains almost 3,000 pages. The focus of our investigation was on only a small part of this report. The IPCC report contains four volumes: the Working Group I Report on the physical science basis of climate change; the Working Group II Report on climate impacts, adaptation and vulnerability; the Working Group III Report on mitigation of climate change; and a Synthesis Report, integrating the main outcomes of these three Working Group reports.

The Working Group II Report contains 20 chapters, eight of which deal with the regions Africa, Asia, Australia and New Zealand, Europe, Latin America, North America, polar regions (Arctic and Antarctic), and small islands (that is, small-island states).

In the Synthesis Report a table is presented, in its Summary for Policymakers, describing 'examples of some projected regional impacts', derived from the eight regional chapters in the Working Group II Report, each containing four statements, which together form 32 statements (see Annex A for a copy of this table). We have considered this table in the Synthesis Report as the highest summary level presenting the most important regional impacts, with the highest visibility to the policymakers.[2)]

The primary focus of this investigation, therefore, was on the foundation of these 32 statements, which are a subset of largely identical statements in the Summary for Policymakers of the Working Group II Report.

2) The Synthesis Report was released a few weeks before the important world climate Summit of the UNFCCC (the UN climate convention) in Bali in December 2007 (also indicated as CoP13). At this conference, the UN parties to the convention took the first steps towards a long-term climate policy strategy following the first commitment period of the Kyoto protocol.

Analysis of the main texts and the summaries

Each IPCC report consists of several layers. Each chapter in a Working Group report contains a main text and its literature references, with an 'Executive Summary' up front. Each Working Group report has both an extensive 'Technical Summary' which synthesises and summarises the information of all chapters, and a brief 'Summary for Policymakers'.

We analysed the Executive Summaries of each of the eight regional chapters, and checked their provenance from the relevant parts of the underlying texts in the main chapters and their key references. We did the same with regional information in the Technical Summary and the Summary for Policymakers of the Working Group II Report. In addition, we checked how these conclusions were entered into the main text of the Synthesis Report, and how they ultimately landed in its Summary for Policymakers (see Figure 2.1).

Registration website

The PBL launched a public website that would be available for the course of one month, in order to give all experts in the Netherlands the opportunity to contribute to our investigation. We asked for submissions of possible errors found in regional chapters of the Working Group II Report. By the end of that month, the PBL had registered 40 submissions; however, most of them were about issues related to the Working Group I Report. Two submissions qualified to be addressed in our report. All submissions and PBL's responses have been published on the PBL website.

Process

We invited the IPCC authors of the regional chapters of the Working Group II Report to comment on our draft findings, and in our communication we went through several iterations. In some cases, we also contacted the authors of cited references. The draft of our report was also reviewed by selected internal and external, national and international experts. Moreover, this project has been conducted under the independent supervision of the Royal Netherlands Academy of Arts and Sciences (KNAW).

Methodology

This investigation has resulted in a report on:

1. findings referring to the foundation for the 32 summary conclusions on regional impacts in the Synthesis Report (main objective);
2. additional findings at lower levels, such as those referring to the foundations for statements on regional impacts in the Technical Summary and Executive Summaries of the regional chapters, and also some findings on parts of the main text that we came across while working on other findings. As our focus was on tracing possible errors that would affect the key messages to policymakers, we were unable to systematically check all statements in the main texts.

For our investigation, we used several criteria for assessing the quality of IPCC statements. First of all, we employed a distinction between obvious factual 'errors' – which we believe require an erratum on the IPCC Fourth Assessment web pages – and 'comments', the latter being critical remarks, made from our specific position of having to assess these statements on behalf of Dutch policymakers. These

criteria were developed 'on the job', while categorising our findings. In total, there are nine criteria, and associated with these are two types of 'errors' (E1-E2) and seven types of 'comments' (C1-C7):

- E1: Inaccuracy of a statement;
- E2: Inaccuracy of literature referencing;
- C1: Insufficiently substantiated attribution, when a certain impact had been attributed to climate change without convincing substantiation;
- C2: Insufficiently founded generalisation, when case studies had been extrapolated to whole regions/sectors without convincing foundation;
- C3: Insufficiently transparent expert judgment, when we could not trace the reasoning behind a statement from underlying texts or literature references given;
- C4: Inconsistency of messages, when found between the different layers in the IPCC report;
- C5: Untraceable reference, when a literature reference could not be found;
- C6: Unnecessary reliance on grey referencing, when reference had been made only to grey literature (literature other than from peer-reviewed journals), while adequate peer-reviewed scientific journal references would have been available;
- C7: Statement unavailable for review, when new information had been introduced after the last review, but was not clearly derived from a content issue raised in this last review.

When a certain statement in the IPCC Fourth Assessment Report would meet all the criteria, the statement was considered to be well founded and reliable.

Melting of Himalayan glaciers

In response to the request from the Dutch Minister for the Environment to provide an update on the melting of Himalayan glaciers, we performed an assessment of the new scientific information that had become available since the publication of the IPCC's Fourth Assessment Report (see Annex B). The average, region-wide, glacier area retreat rate is probably between 0.1 and 0.5% per year. Although the glacier area will shrink substantially this century, especially in the most vulnerable eastern zone of the Himalayas, glaciers (such as Khumbu and Imja), will not disappear entirely, or even mostly, by 2035, as stated in the Working Group II Report.

The annual contribution from Himalayan glaciers to sea level rise is 0.06±0.04 mm or ~2% of the current annual sea level rise of 3.1±0.7 mm. The rate of Himalayan glacier melting appears to have increased over time, but so has sea level rise, and therefore the 2% contribution may still apply.

Dutch land area below sea level

The error about the percentage of Dutch land area below sea level stems from a text submitted by the PBL (see Annex C). The Working Group II Report states that 55% of Dutch land area is below sea level. This should have read that 55% of the Netherlands is prone to flooding: 26% of the country is at risk because it lies below sea level and another 29% is susceptible to river flooding.

Sea level rise and its consequences for the Netherlands

Errors in the IPCC report regarding the Himalayan glaciers and the Dutch land area below sea level have triggered a discussion on whether Dutch policies that deal with sea level rise should be revised (see Annex D). The answer is clearly 'no': the contribution from melting Himalayan glaciers to sea level rise is very limited (around 2%) and the policy concerning safety against flooding in the Netherlands, as formulated in the National Water Policy Plan 2009-2015 (Ministry of Transport, Public Works and Water Management, 2009) and elaborated in the Delta Programme, is well founded on the available knowledge on climate change, sea level rise, river discharges and uncertainties. The current discussions on the IPCC have no effect on the assumptions under the National Water Policy Plan and the Delta Programme.

Part I – Main findings

1 Introduction

1.1 Scientific assessment in aid of policy

The characteristics of climate change qualify it as the most complex type of policy problem. It resists direct perception, hence, making policymakers and the public depend on experts to describe its potentially problematic features. It is a phenomenon, the problematic features of which may manifest themselves within a matter of decades, while preventative measures assume more direct action. It is also a global phenomenon which can only be handled effectively through joint participation of all countries (climate change is a classic 'free rider' problem). Addressing climate change is not a matter of controlling one clearly identified source, as was the case with the depletion of the ozone layer, but rather of controlling a multiplicity of sources. This characteristic of 'wickedness' (cf. Rittel and Webber, 1973) makes that climate science plays a very central role in the policy debate. To make things worse, a full understanding of the subject depends on the input from a large variety of scientific fields, with differing degrees of standing knowledge relevant to measuring and understanding processes of climate change, its effects and possible remedial strategies. Since both the stakes and the uncertainties are high, the problem of climate change needs to be addressed by using 'post-normal science'; a problem-solving strategy that involves paying specific attention to qualitative judgments and value commitments permeating science (Funtowicz and Ravetz, 1993).

The role of assessments

Historically, the IPCC was established to present international policymakers with undisputed, policy-relevant knowledge, while acknowledging uncertainties (see e.g. Petersen, 2006). Since its inception in 1989, the IPCC has been effective at this. However, the science on climate-change impacts is still beset with large uncertainties, some of which are irreducible. Next to the nature of climate science, it is relevant to remember that perceptions of climate-change risk vary widely, both across the globe and within societies (cf. e.g. Hulme, 2009).

Hence, the issue of climate change is complex, both in causes and effects and in terms of policy implications. The uncertainties, different interests and different risk perceptions pertaining to all aspects of causes, consequences and response options are inextricably linked to the issue of climate change.

In such situations, scientific assessments are the institutional vehicle for presenting policymakers with information that would help them define and decide on policy strategies. Scientific assessments present the state of knowledge relevant to a

particular policy problem. It is a subtle tool. For complex problems such as climate change, recent history has shown that a traditional, linear science-for-policy model – one that is based on a clearly formulated policy question followed by a sequence of scientific research from hypotheses to experiments and, finally, agreed on answers – will not work. The nature of the issue is too complex and uncertainties will always remain. However, the fact that uncertainties about climate change are large does not mean that scientific information should not or could not play a role in decision-making. On the contrary, well-formulated scientific information is considered a crucial component in addressing complex policy problems.

The tool of scientific assessment, such as that implemented through the Intergovernmental Panel on Climate Change (IPCC), has been developed as a way of organising the science–policymaker dialogue (see, e.g., Social Learning Group, 2001). Scientific assessment is the analysis and review of information derived from existing research, in the context of specific decision-making processes, in order to better understand the wide implications of a policy problem and to identify and evaluate possible response actions. Such assessment usually does not entail new research. The design of the process of scientific assessment needs to ensure that uncertainties are properly addressed and that different societal perspectives are included in the process, so that politicians may obtain a better sense of the possible futures facing the world, and of the choices that could be made. One of the functions of independent assessments is to assess and communicate uncertainty, and to make sure that the problem is analysed from different value perspectives. The proper course of action then is for policymakers to decide what – if anything – should be done.

The IPCC assessment process

This report investigates the quality of IPCC's key messages on regional impacts of climate change, which were the outcome of a long production process. We have not reiterated the elaborate IPCC production process with its procedures for review. This has been described extensively in the *Principles Governing IPCC Work* (http://www.ipcc.ch/pdf/ipcc-principles/ipcc-principles.pdf; for a summary, see http://www.ipcc.ch/pdf/ipcc-principles/IPCC%20Procedures.pdf). These procedures are meant to guarantee a responsible assessment process.

It is important to note, however, that an IPCC assessment is not the product of an extensive bureaucratic operation. Instead, its organisational structure is aptly characterised as being a network organisation that spans the whole globe. Scientific experts from varying continents collaborate and assemble overviews of the knowledge in their respective fields. The quality and integrity of the IPCC process depends, to a large extent, on the quality and integrity of its procedures, and, hence, on the commitment of all contributing authors to adhere to those rules and procedures. In response to experiences and criticism, these procedures have been regularly upgraded over the course of more than 20 years to guarantee increasing assurance of high levels of quality and integrity.

We have chosen not to elaborate on the institutional set up of the IPCC, but have considered it a given. For the present report, we had set ourselves the task of assessing the transparency with which scientific facts on climate-change impacts

have 'travelled' from their source (e.g., scientific peer-reviewed literature) to their destinations: the Summaries for Policymakers. This final destination of scientific facts within the IPCC process has driven the investigation presented in the present report. The IPCC process should deliver useful and reliable knowledge (cf. Morgan, 2010) to policymakers; one route to check this – followed for this report – is by tracing summary conclusion back to their origins.

The role of expert judgment

This report deals with the questions that have been raised on the reliability of the assessment process run by the IPCC. In particular, questions have been raised concerning the Working Group II contribution to the Fourth Assessment Report with its focus on *Impacts, Adaptation and Vulnerability* and including the regional chapters that were home to the two errors that caused the upset in the media and in society, in the winter of 2009–2010. This report has been based on the assumption that the quality of the IPCC scientific assessment can be measured by tracing statements on the effects of climate change, for example, as presented at the highest level of summaries for policymakers (in the Synthesis Report and the Working Group II Report), back to their original sources. There is obviously a limit to the traceability of such statements. Given the mismatch between the state of standing knowledge on complex environmental phenomena, on the one hand, and the questions raised by policymakers, on the other, those conducting an assessment often have to arrive at so-called *expert judgments*: a weighing of understandings and analyses to come up with the best possible assessment of observations, or of what one might expect to happen. Such expert judgments are a crucial component of any assessment. Given the fact that these judgments cannot be traced back to any one source in the (peer-reviewed) literature, the quality of these assessments grows as the expert judgments are made more transparent, that is, by explaining how particular conclusions have been arrived at. This procedure allows others to follow a certain line of reasoning, similar to how this generally is done in articles published in scientific journals. Another way of enhancing the quality of expert judgments is to present them in the form of a deliberation, stating the way in which key conclusions have been arrived at. This then allows other scientists to contradict inferences, or come up with alternative explanations.

Expert judgments are inextricably linked to assessments and are used in all phases of the IPCC assessment process. The lead authors of the regional chapters of the Working Group II Report were supposed to have read all the literature relevant to that particular region, and to be familiar with the environmental policy issues of that region. Based on their individual expertise, the lead authors collectively arrived at judgments on the impacts of climate change. The review process of the IPCC relies on two rounds of expert review and one round of government review, as well as on Review Editors, who umpire the review process. The objective of this process is to ensure a balance in the lead authors' judgments as these are published in the report. The chapters themselves are very detailed. This explains the need for summary statements that convey the most important conclusions to policymakers. The Coordinating Lead Authors drafted the Summary for Policymakers of the Working Group II Report, and a smaller group of authors (consisting of two regional Coordinating Lead Authors, the two Co-Chairs and the head of the Technical Support Unit of Working Group II) was involved in the drafting of the Summary for

Policymakers of the Synthesis Report. Moreover, in both of these Summaries for Policymakers, the role of expert judgments had been crucial for determining the main policy-relevant findings from the underlying chapters.

Since it is impossible for most readers of IPCC reports to understand and check every reference, all data, models, calculations and measurements, they must be able to rely on the quality control and quality assurances given by the assessment process. To some extent, those readers have no choice other than to assume an expert judgment to reflect the best of current knowledge. However, they should be able to trace the plausibility of a judgment in a Summary for Policymakers back to the main text and references. When dealing with issues as complex as climate change, expert judgment is inevitable. But precisely because this is a matter of sound judgment, there is a virtue in maximising the possibility for others to verify and validate the analyses made by the IPCC authors.

1.2 Some background on IPCC Working Group II

Since the Third Assessment Report (finalised in 2001), the work of the IPCC has been organised into the following three distinct Working Groups:

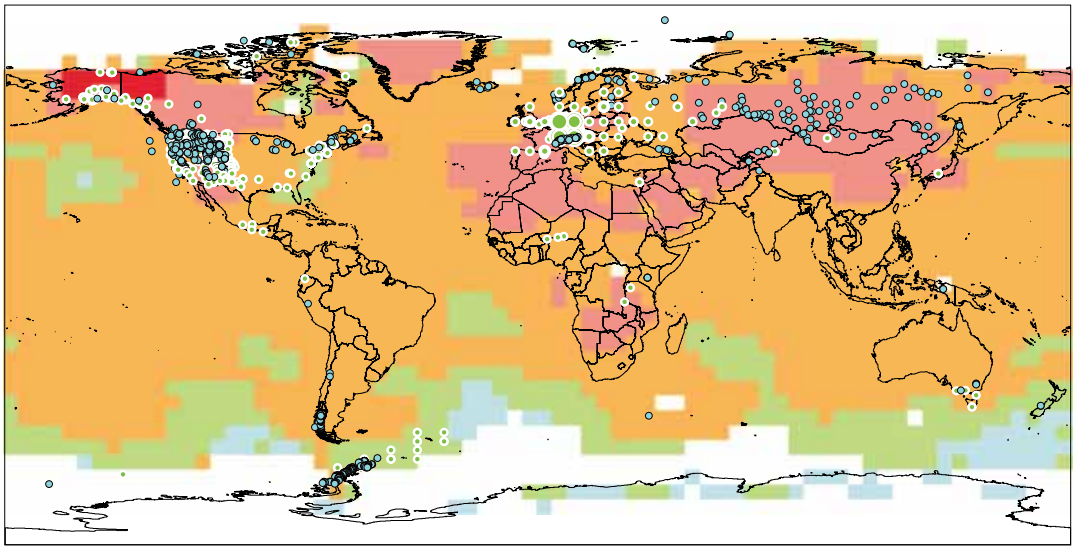
- Working Group I addresses the physical science of climate change;
- Working Group II addresses the impacts of and vulnerability to climate change and the means for adaptation;
- Working Group III addresses the mitigation of greenhouse gas emissions.

Working Group II addresses impacts, vulnerability and adaptation to climate change with respect to human and natural systems. This particular focus calls for the mobilisation of authors mostly from physical, geographical and ecological sciences, but also from the social sciences. The particular thematic focus of Working Group II immediately complicates its assessment task. The interactions within biological systems and between biological systems and physical chemical and social systems, are very complex. What is more, the patterns of interaction vary, depending on local situations and on human choices and actions.

Literature on climate impacts is not only very diverse, and the intensity of academic scholarship is divided very unevenly over the globe. This increases the challenge of making good assessments of what the impacts, effects and vulnerabilities of climate change are in those regions that have the least data to draw on. This point is well illustrated by a map from the IPCC report itself (see Figure 1.1).

Furthermore, impact analyses are not only spread unevenly around the world, it is also a field of study where often insights are found outside of the strict academic tradition. For instance, many impact analyses are presented in reports by governments and inter-governmental or private, non-academic institutions – given the fact that not all topics in these reports are equally suitable for, or indeed, targeted to scientific publication – which complicates the task of assessors. The IPCC guidelines specifically allow for this literature also to be assessed (in order to provide relevant input about local and sectoral situations and to minimise bias in information between developing and industrialised countries, for instance, because

Figure 1.1 **Observed changes in biological and physical systems**



Locations of significant observations of changes in physical an biological systems together with changes in surface air temperature, over the 1970–2004 period. Source: Climate Change 2007: Impacts, Adaptation and Vulnerability. Working Group II Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Figure 1.8. Cambridge University Press.

impacts in developing countries are reported even less in scientific peer-reviewed journals).

The scientific uncertainties that the IPCC, including Working Group II, are confronted with, are large and deep. Since its inception, the IPCC has given increasing attention to the management and reporting of uncertainties (Swart et al., 2009). The socio-ecological systems studied by Working Group II are not always suitable for numerical modelling; hence, there is a lack of information on quantitative uncertainty. Impact analyses or the study of vulnerabilities often depend on empirical observation using different scientific techniques, such as field research or case study analysis. Because of the uncertainties involved, it is difficult to establish which impacts occur, and why and to what extent observed effects could be attributed to climate change. Often authors need to make assessments of the risks that are associated with various levels of climate change, rather than indicating best-estimates and clearly defined uncertainty levels. In order to estimate

the possible risks of climate change, also events with very low probability but with large consequences have to be dealt with.

In the context of this report, it is important to understand the mandate of Working Group II. Formally, Working Group II 'assesses the scientific, technical, environmental, economic and social aspects of vulnerability (sensitivity and adaptability) to climate change and the negative and positive consequences for ecological systems, socio-economic sectors and human health, with an emphasis on regional, sectoral and cross-sectoral issues.' (see http://www.ipcc.ch/working_groups/working_groups.htm)

1.3 Scope, objectives and limitations of this report

In January 2010, worldwide media attention was drawn to two errors that were discovered in a part of the Fourth Assessment Report of the IPCC of 2007: an erroneously high rate of melting of the Himalayan glaciers, and an erroneously high percentage of land area in the Netherlands lying below sea level. The latter error was not the fault of the IPCC but of the PBL (see Annex C). The commotion in the Dutch media and subsequent discussions at the political level in the Netherlands led to a resolution by the Dutch Parliament on 28 January 2010, which declared in the preamble that the reliability of the IPCC, which should be undisputed, was now at issue.

In the resolution, the parliament required that the government would charge the Netherlands Environmental Assessment Agency (PBL) with providing a new update of climate science, including the implications of the said errors. Based on this resolution and the debate in parliament, the Minister for the Environment decided for the PBL to limit its investigation to the implications of possible errors in the regional chapters of the IPCC report of 2007 on climate-change impacts, adaptation and vulnerability.

The assessment presented in this report was based on an investigation of the original sources of the IPCC's Fourth Assessment summary conclusions (in particular, the Synthesis Report, Table SPM.2, see Annex A) that pertain to a part of one of the Fourth Assessment Reports (that is, Chapters 9 to 16 of the Working Group II Report), and was aimed to derive general observations and identify possible improvements.

Two additional tasks were taken on. First of all, the Minister for the Environment asked the Netherlands Environmental Assessment Agency (PBL) to make an assessment of the scientific literature on Himalayan ice, published since 2007. This was triggered by the need to communicate what scientists *do* know about this topic; after all, the public turmoil concerned the IPCC error that stated that all Himalayan ice would be melted by 2035. The results from this assessment are presented in Annex B.

Second, the parliamentary debate also showed concerns over the possible repercussions of the state of knowledge on the issue of sea level rise for climate-

change adaptation measures in the Netherlands. Therefore, the state-of-the-art scientific foundation on this issue is summarised in Annex D.

The PBL has taken the utmost care to prevent possible prejudice in their present assessment of the conclusions derived from the regional chapters of the Working Group II Report. A crucial mechanism to avoid any prejudice was the installation of a supervisory committee under the responsibility of the Royal Netherlands Academy of Arts and Sciences (KNAW). The KNAW was asked to supervise the quality of this PBL study. The KNAW appointed a scientific committee, whose role it was to judge whether the PBL performed its research without prejudice and according to established procedures of quality control.[1)]

Realistically speaking, a thousand-page assessment by hundreds of authors involving thousands of reviewers conducted within a limited timeframe could hardly be expected to be free of errors. Therefore, it is to be expected that some inaccuracies, insufficiently justified statements or other irregularities, escape even the most thorough drafting and review procedures. Our evaluation methodology was to take the statements in the various IPCC summaries as starting points and consider their source of origin (where did they come from?). A full evaluation of the reliability of statements would entail redoing the original IPCC assessments. Our limited evaluation could never have repeated or improved on the IPCC drafting and review process in a comprehensive way, nor was it our aim to redo the IPCC assessment. Nevertheless, we think that such a limited evaluation by scientifically educated policy analysts, who are not experts in climate-impacts science, is a useful means for the IPCC to receive feedback from an extended peer community (cf. Funtowicz and Ravetz, 1993). Through this evaluation, we reflect on the qualitative judgments and value commitments that necessarily permeate the IPCC assessment process.

Without recruiting experts with the range of expertise and following the careful, multi-step review that has characterised the IPCC reports, any review of the contents of IPCC chapters only has limited potential. The current PBL assessment, therefore, extends only to checking whether observations and interpretations had been captured conscientiously, how statements had been substantiated within IPCC reports, and to evaluate the transparency with which important expert judgments had been made. The analysis focused on investigating the 'internal' consistency of the report, and did not perform new, fresh reviews of the evidence available at the time the Fourth Assessment Report was produced. In sum, the analysis focused on assessing statements by looking for errors (inaccuracies in statements and referencing) and by applying a short list of quality criteria (see Chapter 2), which was developed specially for the purpose of this analysis.

In sum, the central questions addressed in this report are the following:

Are the summary conclusions on regional impacts well founded on the underlying chapters and literature references? Are there errors in statements that have travelled

1) The terms of reference of the supervision by the Royal Netherlands Academy of Arts and Sciences can be found at http://www.knaw.nl/pdf/Instellingsbesluit_Toezicht_Cie_PBL.pdf (in Dutch).

from the scientific literature references and/or the main texts through to the summary conclusions? If errors are found, do they affect the validity of these conclusions? What recommendations can we derive from our investigation in order to further improve the quality of the assessment process for the Fifth Assessment Report (due in 2014)?

1.4 Structure of the report

Part I of the report contains the main findings. Chapter 2 describes the methodology of our assessment. Chapter 3 presents the results from our analysis of IPCC Fourth Assessment's statements on regional climate-change impacts. Chapter 4 contains our recommendations for the IPCC assessment process, following from our analysis in Chapter 3. Part II provides our detailed analysis of the regional chapters and the summaries.

References

Funtowicz, S.O. and Ravetz, J.R., 1993. 'Science for the post-normal age', Futures 25: 739–755.

Hulme, M., 2009. Why We Disagree about Climate Change: Understanding Controversy, Inaction and Opportunity. Cambridge: Cambridge University Press.

Morgan, M.S., 2010. 'Traveling facts', in P. Howlett and M.S. Morgan, eds., How Well Do Facts Travel?, Cambridge: Cambridge University Press. (http://www2.lse.ac.uk/economicHistory/pdf/Morgan/Travelling%20facts%20_2_.pdf)

Petersen, A.C., 2006. Simulating Nature: A Philosophical Study of Computer-Simulation Uncertainties and Their Role in Climate Science and Policy Advice. Het Spinhuis Publishers, Apeldoorn and Antwerp. Download from http://hdl.handle.net/1871/11385.

Rittel, H.W.J. and M. Webber, 1973. 'Dilemmas in a general theory of planning', Policy Sciences, 4 (2): 155-169.

Social Learning Group, 2001. Learning to Manage Global Environmental Risks, Volume 1: A Comparative History of Social Responses to Climate Change, Ozone Depletion, and Acid Rain, Cambridge, MA: MIT Press.

Swart, R., L. Bernstein, M. Ha-Duong, A. Petersen, 2009. 'Agreeing to disagree: uncertainty management in assessing climate change, impacts and responses by the IPCC', Climatic Change 92: 1–29.

2 Methodology

2.1 Investigative approach

The two primary aims of the investigation were to assess, first of all, whether errors would affect the content of the IPCC's key statements on regional climate-change impacts, and, second, whether these key statements would meet seven quality criteria formulated by the PBL (see Section 2.2). These key statements were taken from the Summary for Policymakers of the IPCC Working Group II Report (2007) and, in part, presented in Table SPM.2 of the IPCC Synthesis Report (2007) (see Annex A). Figure 2.1 offers a graphical explanation of the area of investigation, Figure 2.1A places the statements on regional impacts of climate change in the context of the whole IPCC Fourth Assessment Report, and Figure 2.1B represents the approach to the chapter analysis. Table SPM.2, containing 32 bulleted statements on the most important projected impacts (four per region), is located at the top of a 'pyramid'.

A secondary aim of our investigation was to identify errors and assess the quality of statements on regional climate-change impacts at levels below the Summary for Policymakers of the Working Group II Report.

In Figure 2.1B, the 'pyramid' shows the analysis levels that we used in our investigation. The Working Group II 2007 Report itself contains four layers. Level 1 contains the main chapter texts, level 2 contains the Executive Summaries of the individual chapter texts, level 3 contains the Technical Summary (giving an extensive overview of the whole report), and level 4 is the Summary for Policymakers (a short document, approved line-by-line by the governments involved in the IPCC). Each chapter text refers to hundreds of literature sources on which the assessment was founded ('level 0'). In some cases, we also investigated a few sources that were mentioned in the literature references ('level –1')

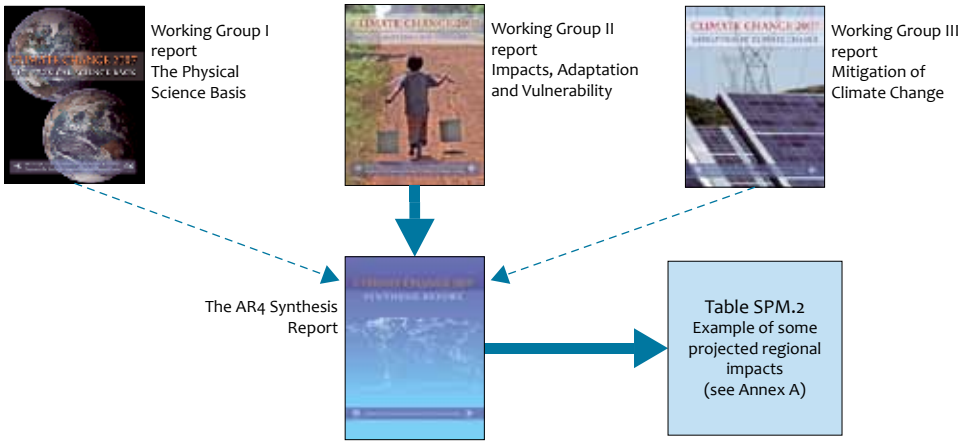
The Synthesis 2007 Report has only two layers, a main report, divided into six topics, and a Summary for Policymakers. The information in the Synthesis Report has a higher level of aggregation than that in the Working Group Reports (level 5). The information in the Summary for Policymakers of the Synthesis Report has the highest level of aggregation (level 6).

The heuristic approach that was followed by PBL policy analysts involved in this study, was to start by reading the Executive Summaries (level 2) of the regional chapters with a critical eye, and from there work upwards to level 6 (Summary for Policymakers of the Synthesis Report) as well as downwards, to level –1. We made

Stucture of the Fourth Assessment Report and regional chapter analysis

Figure 2.1

A. Structure of the Fourth Assessment Reports



B. Regional chapter analysis pyramid

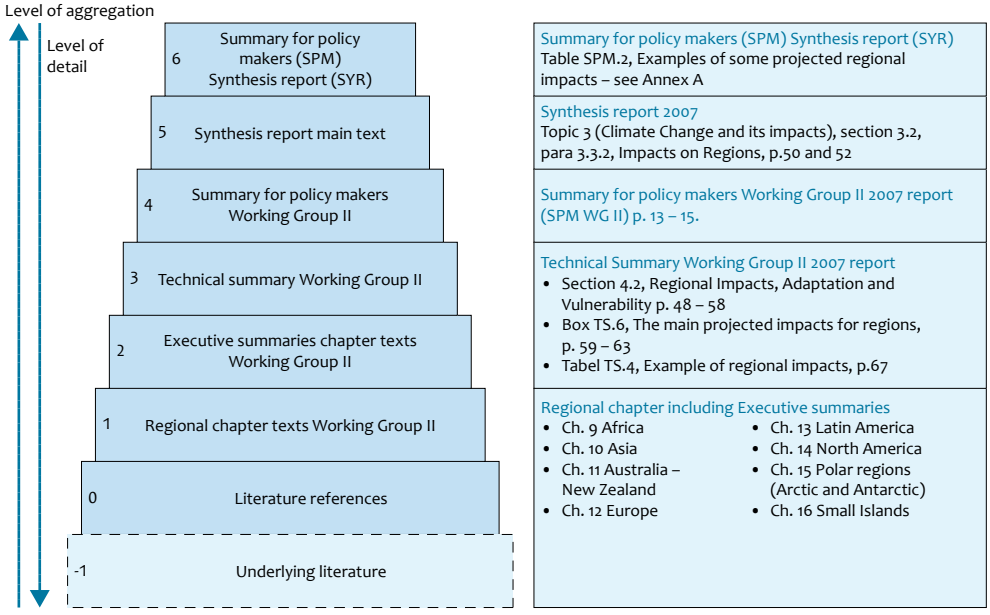


Figure 2.1A shows the structure of the IPCC's Fourth Assessment Report, 2007. The Working Group II Report contains eight chapters (from a total of 20 chapters) describing the impacts in eight world regions. The main conclusions of the reports by the three Working Groups were summarised per report, and also included in the Fourth Assessment Synthesis Report. The last contains examples of some projected regional impacts; see Table SPM.2 (Annex A). This table was the starting point in our investigation. Figure 2.1 B shows the approach to the regional chapter analysis. The statements from Table SPM.2, at the top of the 'pyramid', were analysed by investigating their foundation in the five consecutive levels, and in the relevant underlying literature.

sure that we covered all the bulleted statements in Table SPM.2, looking for any possible weaknesses, thus, effectively working from the top layer of the Synthesis Report down to the more detailed regional chapter texts of the Working Group II Report, and in many cases to the underlying key literature references. In our search for the underpinning of statements, we also looked for evidence in the introductory and sectoral chapters of the Working Group II Report and, when this was deemed necessary, in the Working Group I Report.

Registration website

The PBL launched a public website that would be available for the course of one month, in order to give all experts in the Netherlands the opportunity to contribute to this investigation. We asked for submissions of possible errors found in regional chapters of the Working Group II Report. By the end of that month, the PBL had registered 40 submissions; however, most of them were about issues related to the Working Group I Report. Five submissions were related to the regional chapters of the Working Group II Report; two of those five were included in our report, three submissions did not qualify for inclusion. All submissions and PBL's responses have been published on the PBL website.

Process

We invited the IPCC authors of the regional chapters of the Working Group II Report to comment on our draft findings, and in our communication we went through several iterations. In some cases, we also contacted the authors of cited references. The draft of our report was also reviewed by selected internal and external, national and international experts. Moreover, this project has been conducted under the independent supervision of the Royal Netherlands Academy of Arts and Sciences (KNAW).

2.2 Typology of errors and qualifications

The typology of errors and qualifications ('comments') presented here was arrived at through an inductive process – the results from which are outlined in this section. A distinction was made between 'major' and 'minor' errors or comments. Issues were labelled to be 'major' when we judged them to have a significant quantitative impact on statements pertaining to food, water, ecosystems, coastal areas, and health.

Errors

We used a sharp definition: 'errors' were considered inaccuracies in the IPCC Fourth Assessment Report that we believed to require repair through an erratum or a redoing of the assessment of the specific issue at hand. Experts – in particular, PBL policy analysts and IPCC authors – reached a high level of agreement on what they considered to be an 'error' in this precise sense. Both the Himalayan glacier melting by 2035 and the 55% of the Netherlands that was said to be below sea level, were considered to be such 'errors'.

We distinguished two types of errors:

E1. Inaccurate statement

Statements should be an accurate and correct reflection of the material found in literature, augmented by the expert judgment of a writing team. If a statement appeared to be factually incorrect, then we considered whether this was a minor imprecision or inaccuracy or if a major mistake had been made that could have led to misinterpretations by policymakers. We applied the following subcategories to this type of error:

E1a) *Inaccuracies that can be corrected by issuing an erratum* – This would be mistakes that could be simply corrected without new scientific assessment considerations, such as: typographical errors, incorrect phrasing of part of a sentence, wrong dimensions, and wrong reference years. The error on the percentage of Dutch land area below sea level belongs to this subcategory (see Annex C).

E1b) *Errors that would in fact require a redoing the assessment of the specific issue at hand*, such as: establishing a new range of numbers by revised calculations from the reference sources available during the assessment period, and/ or rephrasing of the expert judgment including its uncertainty labelling.[1)] The Himalayan glacier error belongs to this subcategory (see Annex B).

E2. Inaccurate referencing

References used in statements should be correct. Whenever we found a reference to a wrong source, or when the source was not correctly cited, we qualified this to be *'inaccurate referencing'*. In all cases, an erratum was proposed.

Qualifications

In addition to the errors in the Fourth Assessment Report that could be corrected. either in an erratum or through reassessment, we distinguished between seven types of qualifications or comments that would signify the quality of a statement.

C1. Insufficiently substantiated attribution

In some cases, observed or projected impacts on systems are described as being 'due to climate change', 'temperature increase' or other climate parameters. Since, often, there are other drivers that could be involved in causing such an impact (e.g. population growth, industrialisation, migration, and changes in land use and land cover), care must be taken to provide the proper context in IPCC statements about the effects of climate change, by referring to other causes and/or stresses that may influence the impacts discussed. Statements that, in our judgment, did not sufficiently signal the presence of multiple stresses, or suggested a one-sided attribution of impacts to climate change while other factors also would have been expected to play a critical role, were qualified as *'insufficiently substantiated attribution'*.

1) This, of course, excludes new findings in literature published after completion of the assessment reports.

C2. Insufficiently founded generalisation
In some cases, the impacts, for instance, on certain types of livestock or countries, were generalised or extrapolated to include other livestock or entire regions. In such cases, we believe authors ought to make clear why they think that the evidence in the references justifies such generalisation. Statements, for which such argumentation was lacking, and for which such evidence could not be found in the report or in the references, were qualified as *'insufficiently founded generalisation'*.

C3. Insufficiently transparent expert judgment
Expert judgment on results that can be found in the scientific literature, is an essential part of the IPCC assessment process; this includes giving an indication of uncertainties. An assessment is thus not a simple summary of the literature. The expertise of an international group of authors adds value by judging the importance and relative weight of the information from the literature. For the sake of transparency, we believe that the reasoning behind these judgments, including the reasoning behind their levels of likelihood and/or confidence[2)], should be accessible to a non-expert reviewer who attempts to trace the travelling of facts from the referenced literature to the Summaries for Policymakers.

If, in our opinion, this was not the case, and this fact was found to be problematic, we qualified the particular judgment as an *'insufficiently transparent expert judgment'*. This does not imply that this IPCC expert judgment was wrong, since the authors as a group may have had their reasons, and may have considered additional information or knowledge that was not explicitly referred to. However, in such cases a convincing substantiation of the statement was lacking in the report.

C4. Inconsistency of messages
When moving up from statements in the main chapter texts to statements in the Summary for Policymakers of a Working Group Report or of the Synthesis Report, the sentences were inevitably shortened and the wording may have needed some adjustments. However, Summary for Policymaker texts need to be consistent with the main text, as required by the IPCC procedures. This holds both for the meaning of the message as well as for the level of certainty. SPM approval session decisions include a list of issues that need to be checked for consistency with the Technical Summary and the main chapters in preparation of the final publication. Whenever we found that message content and/or confidence level had changed when it moved from main text to Summary

2) The IPCC authors were in fact requested to produce a 'traceable account' of their assessment of uncertainty in expert judgments in the Fourth Assessment process (see Guidance Notes for Lead Authors of the IPCC Fourth Assessment Report on Addressing Uncertainties, July 2005, http://www.ipcc-wg1.unibe.ch/publications/supportingmaterial/uncertainty-guidance-note.pdf). For the Third Assessment, a similar guidance was given (Uncertainties in the IPCC TAR, 2000, http://stephenschneider.stanford.edu/Publications/PDF_Papers/UncertaintiesGuidanceFinal2.pdf). It is our general impression that this part of the guidance has never been fully implemented in the assessment process. Also, the option to have separate traceable accounts underlying the reports has not been pursued.

for Policymakers and also if there was any inconsistency between chapters, we qualified this as an '*inconsistency of messages*'.

C5. Untraceable reference
As stated before, references used in statements should be accurate. If we could not find the reference at all, we qualified this as an *'untraceable reference'*.

C6. Unnecessary reliance on grey referencing
Grey literature was an indispensable part of the Working Group II assessment (this also applies to Working Group III), since not all relevant literature had been published in peer-reviewed scientific journals. The grey literature needed to meet quality standards before it could be used. There are huge differences in the types of literature, going from thoroughly reviewed scientific books to much less reviewed – or even non-reviewed – publications. When a substantial scientific statement only referred to a grey publication, although strong peer-reviewed journal references could have been referred to at the time, we qualified this to be *'unnecessary reliance on grey referencing'*.

C7. Statement unavailable for review
In the preparation of a Final Draft Report, the results from government and expert reviews were included. This could mean that new literature sources would be added in order to properly address the Second Order Draft (SOD) review comments. Since reviews of a SOD often asked for the addition of sources, such additions had to be considered as acceptable revisions. However, if a new statement contained new literature findings that were not clearly derived from a content issue raised in the Second Order Draft review, then this new material would have been kept out of the review process. This is not supposed to happen; expert reviewers or governments must have access to all findings that will be part of the published report. In the cases in which these new literature findings were added as described above, we qualified them as a *'statement unavailable for review'*.

It is important to note that the assignments to these seven qualifications were not necessarily agreed on by all the experts involved in our investigation, including the IPCC authors. These assignments were based on the judgment of PBL policy analysts who had to establish the reliability of IPCC reports as part of their work at the science–policy interface. The aim of this exercise has been to identify potential areas for improvement in future IPCC assessments. The underlying assumption being that times have changed and that, consequently, quality and transparency requirements for the IPCC have been raised.

3 Results and Discussion

This Chapter consists of four parts. First, it presents the appraisal of the statements on regional climate-change impacts that appear in the Summary for Policymakers of the Synthesis Report. Second, an overview is given of errors found in the Working Group II Fourth Assessment Report. Third, it addresses the approach followed by Working Group to arrive at its summary conclusions on the regional impacts of climate change. And fourth, a thematic overview is given of our comments on the IPCC report, aimed at further improving the IPCC process.

Our detailed analysis of the regional chapters and summaries can be found in Part II of the present report.

3.1 Status of IPCC summary statements on regional climate-change impacts

In this investigation we have not encountered errors that undermine the summary conclusions of the Fourth Assessment Report of the IPCC on the regional impacts of climate change. The Working Group II Report presents ample evidence of observations of climate-change responses by physical and biological systems. Furthermore, the consequences of climate change generally impose a serious risk given the projections on future climate change of Working Group I. However, there is considerable room for scientific debate on statements that refer to climate-change impacts on a regional scale. We have found that, the more specific statements become in time and space, the larger the uncertainties. In addition, the body of scientific publications is smaller, in particular where it concerns local and regional changes occurring in developing countries.

Of all the summary statements on the regional impacts in the Working Group II Report – a subset of which is included in the 32 statements in Table SPM.2 of the Synthesis Report – only one was found to be affected by a minor error. This minor error, in our view, requires a response and reassessment by the IPCC.

Besides checking the summary statements for possible errors, we also tested the quality of these statements with respect to a range of issues: attribution, generalisation, transparency of expert judgment, consistency of messages, traceability of references, credibility of references, and availability of statements for review (see Section 2.2). We have one or more comments to make on seven

Results from PBL analysis for 32 statements contained in Table SPM.2 of the Synthesis Report **Table 3.1**

Region	Topic (and system/sector)	Error in statement?	Comments?
Africa	Water stress (freshwater resources)	Yes (minor)	No
	Yields from rain-fed agriculture (food, fibre and forest products)	No	Yes (major)
	Cost of adaptation to sea level rise (coastal systems and low-lying areas)	No	Yes (minor)
	Arid and semi-arid land (ecosystems)	No	No
Asia	Freshwater availability (freshwater resources)	No	Yes (major)
	Flooding from sea and rivers (coastal systems and low-lying areas)	No	No
	Natural resources and the environment (ecosystems)	No	No
	Diarrhoeal disease (health)	No	No
Australia and New Zealand	Biodiversity loss (ecosystems)	No	Yes (minor)
	Water security (freshwater resources)	No	No
	Production from agriculture and forestry (food, fibre and forest products)	No	No
	Risks from sea level rise and increases in storms and coastal flooding (coastal systems and low-lying areas)	No	No
Europe	Inland flash floods, coastal flooding and erosion (industry, settlement and society; coastal systems and low-lying areas)	No	No
	Mountainous areas (ecosystems)	No	Yes (minor)
	Southern Europe (most systems/sectors)	No	No
	Heat waves and forest fires (health)	No	No
Latin America	Disappearance of tropical forest (ecosystems)	No	No
	Biodiversity loss (ecosystems)	No	No
	Productivity in crops and livestock (food, fibre and forest products)	No	Yes (major)
	Water availability (freshwater resources)	No	No
North America	Western mountains and water resources (freshwater resources)	No	No
	Rain-fed agriculture (food, fibre and forest products)	No	Yes (minor)
	Heat waves (health)	No	No
	Coastal communities and habitats (coastal systems and low-lying areas)	No	No
Polar regions	Biophysical effects (ecosystems)	No	No
	Impacts for human communities (industry, settlement and society)	No	No
	Infrastructure and indigenous lifestyle (industry, settlement and society)	No	No

Region	Topic (and system/sector)	Error in statement?	Comments?
	Vulnerability of ecosystems and habitats (ecosystems)	No	No
Small islands	Sea level rise (coastal systems and low-lying areas)	No	No
	Coastal conditions (coastal systems and low-lying areas)	No	No
	Water resources (freshwater resources)	No	No
	Invasion by non-native species (ecosystems)	No	No

of the 32 statements contained in Table SPM.2 of the Synthesis Report. If the criteria, as used in this investigation for assessing the quality of statements, would be systematically applied in future IPCC assessments, it would become easier for the users of these assessments, such as the PBL, to establish the reliability of IPCC conclusions. Table 3.1 summarises the results for the statements contained in Table SPM.2 of the Synthesis Report.

3.2 Errors

Inaccurate statements (code: E1)

Table 3.2 presents all newly found errors in the regional chapters of the Fourth Assessment Working Group II Report, as well as the error regarding the Himalayan glacier melting and the error about the percentage of Dutch land area below sea level. Of these errors, only one travelled up to the Summaries for Policymakers. The range for the number of people projected to be exposed to increased water stress due to climate change in Africa, by 2020, turned out to have been erroneously calculated by adding up the ranges for African sub-regions that were given in the underlying reference. The author of the original study – who had recently discovered this error – performed a recalculation, which led to a slightly smaller uncertainty range (90 to 220 million people, instead of 75 to 250 million). We considered this a minor mistake, since the difference does not significantly change the message and the original paper did not provide the details that would have allowed the correct computation of this range. In our view, the IPCC should quickly respond to and assess this slight inaccuracy, even though it is not significant given the uncertainties surrounding such projections.

Only one major new error was found, in Chapter 9 on Africa. A projected decrease by 50 to 60% in *extreme wind and turbulence* over fishing grounds was mistakenly represented as a 50 to 60% decrease in *productivity* as a result of changes in wind and turbulence. However, this error and the remaining five other errors that were newly found did not travel to the level of the summaries, and therefore do not affect the summary conclusions. This is also the case for the two errors that were discovered before we began our investigation (concerning the melting rate of the Himalayan ice and the percentage of Dutch land area below sea level).

Inaccurate statements identified by the PBL in the IPCC Working Group II Report and the Synthesis Report of 2007[a] **Table 3.2**

Region	Pages	Error	Major/ minor error	Simple erratum/ response needed	Effect on Summary for Policymakers WG II and Synthesis Report
Africa	11 (SYR), 13, 435, 444	*Increased water stress by 2020* 'between *75* and *250* million people are project to be exposed' should be 'between *90* and *220* million people are projected to be exposed' (see Section 5.1)	Minor	Response needed	Yes
	435, 444	*Increased water stress by 2050s* '350-*600* million people' should be '350-*490* million people' (see Section 5.2)	Minor	Response needed	No
	448	*Productivity decrease in fisheries under doubling of CO_2* 'extreme wind and turbulence could decrease *productivity* by 50-60%, while turbulence will probably *bring about a* 10% *decline in productivity* in the spawning grounds, and an increase *of* 3% in the main feeding grounds' should be '*the frequency of* extreme wind and turbulence *events* could decrease by 50-60%, while *mean* turbulence will probably *decline by* 10% in the spawning grounds and increase *by* 3% in the main feeding ground of anchovy (IPCC proposed an alternative erratum; see Section 5.2)	Major	Erratum	No
Asia	493	*Melting of Himalayan glaciers* The second paragraph of Section 10.6.2 of the Working Group II contribution and a repeat of part of the paragraph in Box TS.6 refer to poorly substantiated estimates on rate of recession and date for the disappearance of Himalayan glaciers (2035). (See Annex B)	Major	Response needed	No
Australia and New Zealand	50	*Observed warming since 1950* '*0.3* to 0.7 °C' should be '*0.4* to 0.7 °C' (see Section 7.2)	Minor	Erratum	No
Europe	547*	*Percentage of Dutch land area below sea level* '*below sea level*' should be '*at risk of flooding*' (see Section 8.2)	Major	Erratum	No
	555	*Decreases in crop yields by 2050* 'legumes –*30* to +5%' should be 'legumes –*14* to +*1*%'; 'sunflower –*12* to +*3*%' should be 'sunflower –*12* to +*1*%'; and 'tuber crops –*14* to +*7*%' should be 'tuber crops –*9* to +*8*%' (see Section 8.2)	Minor	Erratum	No
Latin America	583	*Frequency of hurricanes* 'frequency and intensity of hurricanes' should be 'frequency and intensity of *intense* hurricanes' (see Section 9.2)	Minor	Erratum	No
	598	*People living in water-stressed watersheds* '*Net increases in the number of people* living in water-stressed watersheds' should be '*Number of people* living in water-stressed watersheds *and net increases due to climate change*' (see Section 9.2)	Minor	Erratum	No

[a] These statements pertain to regional impacts of climate change (addressed in Working Group II Chapters 9–16), together with the two known inaccuracies. Unless stated otherwise, the page numbers refer to the Working Group II Report.
* Erratum already published by IPCC (last checked June 25th).

Inaccurate referencing (code: E2)

Table 3.3 provides an overview of all newly found errors in referencing in the regional chapters of the Fourth Assessment Working Group II Report. We found four instances of inaccurate referencing, which could and should be repaired by issuing errata. These inaccuracies have no effect on the summary conclusions.

Table 3.3 **Inaccurate references newly identified by the PBL in the IPCC Working Group II Report of 2007, Chapters 9–16**

Region	Page	Proposed erratum
Asia	59, 471	*Coral reefs* The reference to Wilkinson (2004) should be replaced by Wilkinson (2000) (see Section 6.2)
Australia and New Zealand	518	*Great Barrier Reef* The references to Berkelmans et al. (2004), Crimp et al. (2004) and Jones et al. (2004b) should be replaced by a reference to Sheehan et al. (2006) (see Section 7.1)
Latin America	598	*Water supply* The references to Vásquez (2004) and UNMSM (2004) should be interchanged (see Section 9.2)
Small islands	697	*Freshwater lens* The reference to World Bank (2000) after 'would reduce the freshwater lens by 65%' should be replace by Falkland (1999) (see Section 12.2)

The errors traced in the investigation presented above do not undermine the conclusions of the IPCC on the regional effects of climate change.

3.3 Risk-oriented approach

The authors of the Summary for Policymakers of the Working Group II Fourth Assessment Report – and especially those of the Summary for Policymakers of the Synthesis Report – during the Fourth Assessment were asked by the Working Group II Co-Chairs to identify the conclusions in the Working Group II assessment as 'key findings'. These key findings would, in turn, be described in two ways: as textual descriptions of 'main projected impacts', and as a tabulated range of possible impacts scaled to climate change. With regard to the main projected impacts, examples of those that travelled to the Synthesis Report, Co-Chair Dr. Parry, explained the approach to us as follows:

> *'In outline: i) we asked author teams to identify a) a tabulated range of impacts for which uncertainty ranges were known and b) a description of the 'main projected impacts' (as well as vulnerabilities and adaptation issues); ii) we made clear that by 'main' we meant the most significant challenges and opportunities that need to be faced; iii) we asked that each author team's list should cover the main relevant impact fields (e.g. water, food, health, coasts, ecosystems, etc.) but not exhaustively if some were not relevant; iii) reviewers and review editors commented on the selection of main projected impacts, and the lists were frequently revised; v) the order of listing is not a rank order; vi) there should be a line of sight connection between the listings of conclusions, i.e. from executive summary of the chapter, through the Technical Summary, the Summary for Policymakers of the Working Group II Report and the Synthesis Report, but vii) the wording of the conclusions might need to vary according to its context in these different places. . . .*
>
> *[Thus] our conclusions list the main projected impacts. Most of these impacts involve potential losses in human welfare and therefore are negative. This stems from two things: i) because the balance of impacts is, indeed, negative in welfare terms and also ii) because positive impacts can often be exploited by mechanisms other than policy, i.e. autonomous adaptation.' (Parry, personal communication, 20 June 2010)*

The approach of Working Group II towards the selection of specific conclusions from the regional chapters has thus focused on which impacts would be the most important for policymakers to respond to.

The Synthesis Report, on page 47 (Section 3.3 on 'Impacts of future climate change'), gives a brief explanation of the selection of the particular key findings:

> *'The following is a selection of key findings14 regarding the impacts of climate change on systems, sectors and regions, as well as some findings on vulnerability, for the range of climate changes projected over the 21st century.'*

Footnote 14 specifies the selection criteria:

> *'Criteria of choice: magnitude and timing of impact, confidence in the assessment, representative coverage of the system, sector and region.'*

And in the Summary for Policymakers of the Synthesis Report, the note to Table SPM.2 ('Examples of some projected impacts') states:

> *'The magnitude and timing of impacts that will ultimately be realised will vary with the amount and rate of climate change, emissions scenarios, development pathways and adaptation.'*

As a result of the approach that was followed, mostly negative impacts were singled out (see Table SPM.2, reproduced in Annex A of the present report). In fact, the reason why hardly any example of a positive impact of climate change can be found in Table SPM.2 of the Synthesis Report is that, according to the IPCC authors, most of the positive impacts were not of sufficient policy relevance. The Working Group II Co-Chair further explained the following:

> *'i) most main impacts are negative, because mankind's activities are generally tuned to current climate, not to something different from that; most change therefore implies a cost; ii) in net welfare terms, as Working Group II found, aggregate impacts are indeed estimated to be negative (see much of Chapter 20 of the Working Group II Report, summarised on page 17 of the Summary for Policymakers); iii) autonomous adaptation is better at making more of opportunities than protecting against the adverse, and iv) policy is experienced in providing protection against the adverse.' (Parry, personal communication, 20 June 2010)*

We labelled this approach to summarising as a 'risk-oriented' approach – mainly, because it implicitly guides assessors to focus more on risk than on opportunities. We believe that this risk-oriented approach has been implicit in the process to arrive at conclusions based on the chapters and that by accepting its outcomes it has in effect been approved by all the governments. The consequence of this approach for which facts did or did not travel to the highest levels of summary, can be illustrated by several examples. For instance, the focus in Table SPM.2 of the Synthesis Report is on crops for which yields are likely to be reduced in Africa, but the table does not mention the crops for which yields are likely to increase due to climate change. For Australia and New Zealand, Table SPM.2 shows many risks but only one benefit of climate change (initial benefits for agricultural production

in New Zealand), while Section 11.4 on key future impacts and vulnerabilities concludes: 'climate change is likely to give rise to six key risks in specific sectors. […]. There are also four key benefits for particular sectors.' Furthermore, in Africa, also *decreases* in the numbers of people suffering from water-stress due to climate change are projected for some areas. Of course, these numbers cannot be simply subtracted from increases in water stress elsewhere (other people are involved), but they constitute potential positive effects of climate change. Finally, an example of a selection against mentioning the positive effects of climate change was found with respect to the likely positive effect of climate change on forest production in North Asia (Russia), which some policymakers may find to be of relevance to their decision making. This potentially positive effect did not reach the Summaries for Policymakers, partly because the authors attached a 'medium confidence' to their statement.

A second aspect of the risk-oriented approach that was followed by the Working Group II Fourth Assessment Report, is that in summary statements on the impacts of climate change, information rightfully was provided on the *climate-change* risk. However, this information was often not contextualised in the summary statements by also mentioning other impact factors. This was even the case when these other factors were much larger than the impact that was attributable to climate change. To give an example, Arnell (2004) showed that the number of people living in water-stressed watersheds (defined as having less than 1,000 m^3 of water per year, per person), even without climate change, would rise strongly over time (a rise of 1.5 to 2 billion people by 2025, globally, compared to 1995, see his Table 5), mainly due to population growth in already water-stressed areas. This increase is much larger than the additional increase related to climate change. Again, some policymakers may wish to see both numbers – that is, changes with and without climate change – within the same context in a summary.

A third, and final, characteristic of the risk-oriented approach is that, often, the upper ends of uncertainty ranges (the worst outcomes that are projected) were highlighted. One example comes from the chapter on Australia and New Zealand, in which 60% of the Great Barrier Reef was projected to regularly bleach, by 2020. This percentage is at the upper end of the uncertainty range. Another example, in the Synthesis Report, in Table SPM.2, is the illustration of the risk of species loss in the European mountains, by the statement 'in some areas up to 60% under high emissions scenarios by 2080.' This statement highlights the upper end of the uncertainty range (the most sensitive situations and the scenario with the most impact), and does not specify the whole uncertainty range; although the words 'up to' signal that there is a range, only the upper end was specified, causing it to be highlighted.

We believe it is appropriate – and even necessary – to apply a risk-oriented approach to climate-change impact assessment. It is a common approach in the fields of, for example, public health, public safety, and anti-terrorism. Nevertheless, we note that the nature of such an approach, especially for the Summary for Policymakers of the Synthesis Report, could easily go unrecognised by readers. The legitimacy of the findings could be increased if the reader would be explicitly informed about the fact that a particular approach has been employed. However,

we feel that a risk-oriented approach is not enough. After all, some policymakers may wish to also receive information on the positive regional consequences and the full ranges of uncertainty at the highest level of summary. Therefore, a more explicit discussion on this issue in the IPCC Plenary may be considered.

3.4 Comments

In this investigation, besides looking for errors, we have evaluated the quality of statements on regional climate-change impacts in the IPCC Fourth Assessment Report by using seven criteria (see Section 2.2). A full account of our findings is given in Part II. In the section below, an overview is given of our main comments, grouped along our seven criteria.[1)]

Attribution (code: C1)

The regional chapters in the Working Group II Report are typically judicious in separating out the impacts that they attribute to anthropogenic climate change. In the text examined, only one instance was found of an 'insufficiently substantiated attribution' (major comment), in which a future attribution is questionable and more care should have been taken to specify what part of a projected change depends on climate change as its driver.

In the Technical Summary, in Table TS.4, the number of additional heat-related deaths per year is given for Australia, with the suggestion that all 3,000 to 5,000 additional heat-related deaths projected for 2050 would be dependent on an increase in temperature. However, a large part of this increase is solely due to changes in population size and age distribution (see Section 7.2). In future assessments, even more care must be taken to prevent insufficiently substantiated attributions.

Generalisation (code: C2)

In most cases, the generalisations contained in the regional chapters are well-underpinned by the chapter material. In the text examined only two instances were found where the generalisation is questionable (both major comments). Two statements in Table SPM.2 of the Synthesis Report involve 'insufficiently founded generalisations'. First, it is questionable whether freshwater availability will decrease in all parts of Asia as indicated (Central, South, East and South-East Asia) (see Section 6.1). Second, it is questionable, on the basis of evidence presented in the chapter, whether productivity will decrease also for livestock farming other than cattle, and, more generally in Latin America, because the evidence provided relates only to Bolivia and Argentina (see Section 9.1). In future assessments, more care must be taken to prevent insufficiently founded generalisations.

1) Part II also presents five of our comments that do not fit our qualification categories. Among these, there is one major comment on the ambiguity of the meaning of phrases such as 'in the Sahelian region' (see Section 5.3).

Transparency of expert judgment (code: C3)

One of the main findings of our investigation is that, for six out of the 32 key statements on climate-change impacts in different regions (Table SPM.2), the regional chapters insufficiently convey the IPCC authors' reasoning behind their weighing of the evidence that was available from the literature ('insufficiently transparent expert judgment'). For other important statements in the regional chapters, also, information on the reasoning behind them was lacking. Expert judgment will always have to play a crucial role in IPCC assessments, or in fact in any assessment. But in those cases where readers may wish to ascertain the reliability of a statement, having the authors' reasoning explained in the text would be of great help in improving the credibility of the claims made.

Below, by way of example, is a list of six questions pertaining to statements in Table SPM.2, which we were unable to find the answer to, on the basis of the regional chapters and the references contained therein:

1. Why is a projected decline in cereal yields in dry years in Morocco, by 2020, representative of an overall decline in yields in 'rain-fed agriculture' in 'some countries' in Africa? (see Section 5.1) (major comment)
2. With respect to the cost of adaptation to the projected sea level rise in Africa towards the end of the 21st century, we asked: how was the range of 0 to 156% of GDP for different countries in the referenced study translated to a 5 to 10% range for the whole continent? (see Section 5.1) (minor comment)
3. In which way is the information about changes in 'freshwater availability' in Asia (which in the chapter is given in both absolute flows and per-capita availability) combined to arrive at the assessment that freshwater availability is projected to decrease in many parts of Asia by the 2050s? (see Section 6.1) (major comment)
4. The report provides information on the range of temperature change for which a regular bleaching of 60% of the Great Barrier Reef is expected; how was this temperature range converted into the statement that this level of bleaching would be reached by the year 2020? (see Section 7.1) (minor comment)
5. What is the underpinning for the projected loss of up to 60% in plant and animal species, in some European mountainous areas, under high emissions scenarios by 2080 – given that the references named in the chapter only state this percentage in relation to plant species? (see Section 8.1) (minor comment)
6. How was the large range (from negative to positive) of projected changes in yields of rain-fed crops (varying over crops and locations) for North America translated to a 5 to 20% increase in 'aggregate yields'? (see Section 10.1) (minor comment)

Relying on expert judgment is a necessary practice in situations where well-researched findings are scarce and potential risks are great. In such situations, the joint deliberation of experts may simply be the best available way to make an assessment. Yet, the transparency of the reasoning in such a deliberation would enhance the verifiability and hence the potential credibility of the assessments that experts arrived at. This investigation ex post reconstructed some of the reasoning. Through communication with the IPCC authors, a large part of the answers was received (these answers have been included in Part II), which led to an increase in our confidence about the statements. Although, for a significant part of the cases, the IPCC authors, when asked, were able to reconstruct their reasonings

and convey them to us, we are convinced that, especially for statements that are included in the Summaries for Policymakers, it is necessary in future assessments to have such reasoning available in the underlying material (chapter texts).

Consistency of messages (code: C4)

Our investigation revealed only two instances of inconsistencies (minor comments) within the report. This concerned inconsistencies in the likelihood level of increases in fires in Australia and New Zealand ('likely' according to the main text of Chapter 11 and 'virtually certain' according to the Executive Summary of the Chapter) and inconsistencies in the confidence level about the relevance of past experience with extreme events to policy-making on adaptation in Europe ('high confidence' in the Executive Summary of Chapter 12 and 'very high confidence' in the Technical Summary and Summary for Policymakers). Such minor flaws could have been prevented by even more careful cross-checking and editing than was done for the Working Group II Fourth Assessment Report.

Another issue related to consistency of messages is the general lack of specification in the summaries about baseline years or periods related to the statements. Part II does not address this issue, since it deals with individual statements; here it is flagged as a more general issue. Variable baselines (20th century; 1961-1990; 1990; 1995; 'today') are used in the regional chapters of the Working Group II Report (as well as in the underlying references), but many statements in the summaries are vague about which particular baseline is being assumed for the projected 'changes'. For qualitative accounts this is less important, but baselines need to be crystal clear when numbers are involved, since these are sensitive to the choice of baseline. Ideally, baselines should be the same throughout a report, but this is not always possible.

Traceability of references (code: C5)

Of the references that we checked, only very few turned out to be untraceable. For instance, the projected 'up to 50%' reduction in yields in rain-fed agriculture for some countries in Africa, was ultimately based on an untraceable reference (MATUHE, 2001). Given the high importance attached to the statement, this is a major comment. On several other examples we had only minor comment to make. A hyperlink turned out to be outdated; it probably has been functioning in 2006/2007, but it was not in 2010 (FAO, 2002, see Section 9.2). Yet another example concerns a paper on a projected increase in coffee-leaf miners in Brazil, which was listed in the references of Chapter 13 as 'submitted' to *Climatic Change*, but we found that the paper had never been accepted by this particular journal, which makes this reference untraceable. Although we found a paper with the same title that was published in 2008, in *Pesquisa Agropecuária Brasileira, Brasília*, the paper had not been accepted by any journal at the time the IPCC report was published. It would be our advice that papers may only be used as literature reference in future IPCC reports if they have been accepted for publication prior to the publication date of the IPCC assessment report.

Credibility of references (code: C6)

Only two instances were found of statements relying on references to grey literature, when literature published in peer-reviewed journals was also available to

which referencing would have been more appropriate. For example, the statement that up to 40% of the Amazon Rainforest could react drastically to even a slight reduction in precipitation was underpinned by a reference to a peer-reviewed WWF/IUCN report of 2000 on forest fires, while – in this case – also more relevant high profile peer-reviewed journal articles had been published by Cox et al. (2000; 2004). In our opinion, this issue deserves more attention from IPCC authors in the future. We consider it a minor comment.

Availability of statements for review (code: C7)

In one instance, we found that a new, quantitative conclusion was added after the Second Order Draft had been completed, without there being sufficient grounds from review comments for such an addition. This statement, on the 'up to 50%' reduction in yields from rain-fed agriculture for some countries in Africa, thus, had been unavailable for review, while it was allowed to travel from an untraceable source up to the highest level of summary (Table SPM.2 of the Synthesis Report). This is a major comment. It is our conviction that such high-impact information should have been made available for review, and that this is applied in future IPCC reports.

3.5 Conclusion

No significant errors found in summary conclusions

The foundations for thirty-two IPCC Fourth Assessment summary conclusions on the regional impacts of climate change have been investigated. These conclusions show examples of projections of climate-change impacts on food, water, ecosystems, coastal regions and health, for all the earth's continents. These conclusions have not been undermined by errors, although one of the conclusions contains a minor inaccuracy: in hindsight, not 75 to 250 million people, but 90 to 220 million people are projected to be exposed to increased water stress due to climate change in Africa, by 2020.

The provenance of summary statements needs to become more transparent in future reports

Seven of the investigated 32 conclusions on the regional impacts of climate change contain information that we were unable to sufficiently trace to the underlying chapters in the IPCC Working Group II Report or to the references therein. For two of these conclusions, our critical comments pertain to insufficiently founded generalisations from existing scientific research, in both cases from local to regional scales, and for one of them also from one type of livestock to livestock in general. While acknowledging the essential role of expert judgment in scientific assessments, the PBL recommends to improve the transparency of these judgments in future IPCC reports.

The regional chapters: one error and some comments

In the underlying regional chapters, in addition to the two already known errors about the melting of the Himalayan glaciers and about the Dutch land area below sea level, another significant error was found: a 50 to 60% decrease in productivity in anchovy fisheries on the African west coast was projected on the

basis of an erroneous interpretation of the literature references. We found certain inaccuracies, ranging from (very) small errors in numbers to imprecise literature references. In addition, we have some critical comments to make. One of them relates to the fact that the report does not specify how many of the additional heat-related deaths projected for Australian cities are actually attributable to climate change – a sizeable fraction is due to demographic changes alone. However, these shortcomings do not affect the investigated 32 summary conclusions or other parts of the IPCC summaries.

Examples of negative impacts dominate at summary level

The IPCC Working Group II Report focuses on climate impacts, adaptation and vulnerability. It was found that, in the IPCC's highest level summary, the conclusions that were derived from the regional chapters of the Working Group II contribution to the Fourth Assessment Report single out projections of *negative* climate-change impacts. Our investigation revealed that IPCC authors considered these to be the most relevant to policymakers. The PBL has labelled this as a 'risk-oriented' approach, which had been implicitly endorsed by the governments that constitute the IPCC (including that of the Netherlands). The PBL subscribes to the importance of an approach that highlights what may go wrong under unmitigated climate change, but the Fourth Assessment Report lacked a clear explanation of the choice of approach and its consequences. Alternatively, it could be argued that policymakers should be presented with a complete picture in the Summaries for Policymakers, not just with negative examples (without suggesting that potential positive effects cancel out potential negatives effects).

No consequences for overarching conclusions

Our findings do not contradict the main conclusions of the IPCC on impacts, adaptation and vulnerability related to climate change. There is ample observational evidence of natural systems being influenced by climate change on regional levels. And the negative impacts under unmitigated climate change in the future pose substantial risks to most parts of the world, with risks increasing at higher global average temperatures.

4 Recommendations

Based on our findings and conclusions in the previous chapters, we present recommendations for the Fifth Assessment Report process. Again, there will be four assessment reports (by Working Groups I, II, and III and a Synthesis Report), due in 2013 and 2014. The report by Working Group II will consist of two separate volumes; a sectoral part A and a regional part B (IPCC, 2009). Our recommendations primarily apply to part B of the Fifth Assessment Report by Working Group II, although most of our recommendations may also apply to the entire Fifth Assessment Report.

4.1 Minimising the risk of errors

In comprehensive scientific assessments of thousands of pages that refer to a large corpus of scientific work, errors are inevitable, especially when dealing with quantitative information. The current IPCC review process is meant to be instrumental in removing errors that creep into the texts during the writing of the several drafts. If errors do occur in the main texts, they rarely propagate to the level of the Summary for Policymakers, since this relatively short text of approximately 15 pages is reviewed and approved line by line, word by word by the IPCC Plenary. In our investigation, we found only one minor error in the investigated 32 statements.

However, the full range of IPCC reports is supposed to be authoritative, also in the underlying texts. Therefore, as much as possible, errors need to be detected and removed. With regard to finding and correcting errors, we believe that an open, pro-active and transparent policy, involving wide circles of the assessment report users, would increase the reliability of IPCC, given its recent increased visibility and public exposure. It is a complex and highly dynamic field. Small mistakes belong to this process and should not be seen to jeopardise the overall credibility of science. However, concerns about statements that are made in such elaborate assessments are inevitable. By enabling constant updating of documents and by publishing 'errata' as an integral part of the process, the IPCC may strengthen the societal legitimacy of its work.

In light of the above, we recommend:

- *Create a public registration website for the submission of possible errors found in the published report.* Errors are inevitable, therefore, the IPCC should make provisions to deal with these, immediately following publication of an IPCC report. Since a few months, erratum pages are available on the IPCC website for the Fourth Assessment Reports of 2007. For the Fifth Assessment Reports to be published

in 2013 and 2014, such erratum pages should be made available directly after publication. In addition, we suggest the launch of a public registration website for the reporting of possible errors. Subsequently, these errors (e.g. regarding numbers or typographic errors), when found to be genuine, could be quickly corrected by publishing them on the erratum website. For more substantial errors, additional comments and explanations from the IPCC should be added and also posted on the website. From our own recent experience, we believe that such a registration website, if designed properly, would be manageable. Experience with this approach may be gained by setting up experimental registration websites for the two upcoming Special Reports in 2011.

- *Check and double-check references*. More checks should be done with regard to accurate referencing to the scientific literature, which should always be traceable and available for reviewers. With regard to the traceability, a user-friendly option would be to create hyperlinks within the text leading to the original publications.
- *Investigate possibilities of pre-publication 'crowd sourcing'*. Finding errors, notably in numbers, is a time-consuming effort for authors, reviewers, Co-Chairs and Technical Support Units, who already are limited in terms of time and resources. The possibility of using 'crowd sourcing' technologies as part of the review during the last stages of completion, therefore, should be investigated. Crowd sourcing has the advantage of providing a large reservoir of voluntary resources to be tapped. A disadvantage could be the amount of resources needed to manage and moderate tasks that would be handed out to the public.

4.2 Investing in the improvement and transparency of foundations of summary conclusions

The findings in Section 3.4, and the more detailed analysis in Part II of this report, lead us to the following recommendations:

- Make sure that statements that attribute impacts to climate change are well founded in scientific research, including systematic observations, modelling and statistics. The climate-change component of impacts should be carefully characterised.
- Make sure that expert judgments that are incorporated in summaries are made transparent and plausible by explaining the line of reasoning behind them in the main text. This applies especially to:
  - case-study generalisations to whole sectors, areas or regions; such generalisations should be well supported by scientific evidence;
  - choosing certain intervals of specific numbers from a wide range of figures.

  This would be a great help to any institute that is asked to assess the plausibility and reliability of statements, and could enhance the credibility of the assessment process. Authors are faced with the dilemma that strict limitations on page lengths are imposed by the Working Group management, limiting the amount of information that can be included.
- Check and double-check consistency of messages and confidence intervals/likelihood levels between chapters and different summaries.
- Grey literature should only be used when peer-reviewed scientific journal literature on a certain subject is not available.

4.3 Strengthening the quality control by the chapter teams

IPCC authors work on a voluntary basis, or their work is a part of their regular jobs as scientists and, often, it is an addition to their regular workload. The budget for the IPCC organisation is relatively small, and assessment time lines are kept very strict. The high cost-effectiveness is both a strength and a weakness in the IPCC process.

The amount of scientific literature on climate change is skyrocketing, policy implications become more visible and, recently, the credibility of the IPCC has come under scrutiny by the media. This implies a need for higher quality standards, next to a future increase in the amount of assessment work. Moreover, Coordinating Lead Authors have to manage their writing teams, and deal with large flows of information within a limited amount of time. Therefore, we recommend that a procedure is set up – within the shortest possible time frame, and which will be implemented at the very beginning of the writing process – for appointing and employing chapter assistants who will help the Coordinating Lead Authors with quality-control issues, such as the checking of references (including basic checks on quantitative information), the cross-checking between findings on regional and sectoral levels, the cross-checking between statements concerning regional climate projections in the Working Group II Report and those in the report by Working Group I. In order to make all this possible, a serious increase in the contributions from the governments that are involved in the IPCC would be necessary.

4.4 Strengthening the review process

We recommend that certain improvements are made in the review process, in order to further minimise the risk of errors and to improve the foundation of the summary conclusions:

- *Ensure that all texts are fully covered by expert reviewers*. The current review process is generally rather passive — expert reviewers are free to comment on those parts of the text that they are interested in, but there is no guarantee that qualified expert reviewers will scrutinise all parts of all texts including the references. A pro-active targeted expert review is therefore recommended. The IPCC could establish a web-based nomination procedure, in which experts subscribe to reviewing certain parts of a report. The Co-Chairs and Technical Support Units could then select the experts and see to it that all parts of the texts are covered by at least a few qualified reviewers.
- *Do not allow new material to be introduced after the last review if this material is not related to the review*. After the Second Order Draft review, new material should only be added if it is clearly in response to, or related to substantive issues raised in review comments. Otherwise, newly introduced material would be excluded from expert review. The IPCC procedures should stipulate more clearly how new material should be dealt with.
- *Do not allow referencing to scientific articles that have been submitted but not (yet) accepted for publication* by the time the IPCC assessment report is published. This has already been good practice in many of the IPCC reports, but IPCC procedures should provide some ruling on this issue.

- *Review by governments of the foundation and provenance of statements in Summaries for Policymakers*. Governments have an important responsibility in the review process and, therefore, should seriously invest in the government/expert review of Second Order Drafts. Apart from the reviewing of issues of specific national interest, governments, assisted by independent experts, could review provenance and foundations for statements in the draft version of the Summary for Policymakers. This report provides an example of how this could be done methodologically. Since this would be a time-consuming effort that draws from many resources, the IPCC could consider extending the expert/government review period for the Fifth Assessment Report. Governments could work together in this process and share resources. In addition, this would provide them with a solid frame of reference for the line-by-line approval session of the final Summary for Policymakers.

4.5 Timing of the assessments

The quality of regional chapters could be further improved by making better use of information that is available in the sectoral chapters of Working Group II reports. The best way to achieve this would be to finalise regional chapters *not until* sectoral chapters have become final. This would help to integrate information at regional levels and contribute to the transparency of the expert judgments. In particular, this can help to provide stronger underpinning of generalisations of case studies to entire regions or sectors, by also making use of regional modelling studies.

4.6 Balancing the assessment of climate-change impacts

The section on 'risk-oriented approach' (3.3) reveals that, at summary level, the most important negative impact projections have been highlighted. This approach is understandable and justifiable, but it has not been made explicit. We believe that such a risk-oriented approach, although essential, is also one-sided. It could be argued that the Summary for Policymakers should provide policymakers with a full picture; it should not only present the most important negative examples (without suggesting that potential positive effects cancel out potential negative effects). We recommend that the Fifth Assessment Report explains which approach has been taken.

In addition, we suggest that a Summary for Policymakers includes two separate sections dealing with projected regional impacts on water, food, ecosystems, coastal regions and health, divided as follows:

- One section that describes robust outcomes, with the full range of projections of climate-change impacts, including not only the uncertainties, but also any positive impacts, containing:
  - A description of uncertainties, as has been employed by Working Group III in their report in the Fourth Assessment. Per statement, an indication could be given of the amount of evidence (number and quality of independent sources) and level of agreement (on a particular finding). At summary level, the first choice would be to highlight statements that are based on a large number of

publications all converging to the same conclusions. 'Likelihood' statements could only be made if sufficient scientific evidence would be available, and 'confidence' statements would be expert judgments, which are subjective by nature and, normally, are untraceable for the reader;
  - An indication of the relative importance of other drivers that affect food, water, ecosystems, coastal areas, and health, compared to drivers of climate change, such as population growth, industrialisation and land use. The impacts that can be attributed to climate change should be separated, as clearly as possible, from those that are caused by other factors.
- One section that explicitly describes the most important negative impacts, as was done for the Fourth Assessment Report, but this time including a *worst-case* risk approach, based on clearly explicated risk assessment methodology. This section could highlight future impacts that may be unlikely to occur, but could have major consequences, and therefore would pose significant risks. Such a section could also include more speculative projections of high climate sensitivity, accelerated warming, and tipping points in ecosystems. An exploration of such an approach has been presented in the PBL study '*News in Climate Science and Exploring the Boundaries*' (December, 2009).

Reasons to consider this line of action include:

- The outsiders of the scientific community that study impacts, adaptation and vulnerability, will not automatically understand the 'risk-oriented approach', as we have labelled the Working Group II approach that leads to a sample of the most important negative impacts. Working Group I followed a different approach, establishing the full range of possible projections including its uncertainties. Without proper explanation, the results at the summary level of Working Group II could easily be interpreted as being an alarmist view (as was our interpretation at the outset of our analysis, before we received further explanation from the Working Group II Co-Chair and authors).
- We believe that policymakers (and their analysts) need to see the complete picture at summary level. Positive impacts are important, because they may also become smaller when mitigation measures are introduced. There may be offsets possible between positive and negative impacts of climate change, for instance, in relation to agricultural yields. Although there are justifiable objections against making a cost-benefit analysis of positive and negative impacts, to not mention them would be 'policy-pre-emptive'.
- In order to obtain a complete picture, we also believe that policymakers – in both public and private sectors – would need to be informed about the worst-case risks, when they are developing risk management, disaster prevention and insurance policies.
- Finally, some of the comments made and the errors found – including those received through our registration website – were related to the issue of accentuating or even heightening the severity of climate-change impacts. We recommend that the authors of the Fifth Assessment Report (AR5) be made specifically aware of this issue. Care should be taken with phrasing of statements that could be perceived by readers as heightening the projected impacts of climate change.

4.7 Investing in climate-change impact science

Climate-change impact science is relatively young, although the amount of literature is expanding rapidly. Figure 1.8 in the Working Group II Report and Figure SPM.1 in the Synthesis Report (see Figure 1.1 in this report) show that there are many observational data available on Europe and the United States that indicate physical and biological changes, over time, but there is only a small amount of observational data available on such changes in developing countries, while developing countries are more vulnerable to climate change. In addition, model projections become more uncertain at geographically more detailed levels, while policymakers ask for concrete information on their specific region or location.

This calls for intensifying investments in regional climate impact observation systems, regional modelling and capacity building, particularly in developing countries

References

IPCC, 2009. Chapter outline of the Working Group II contribution to the IPCC Fifth Assessment report (AR5), http://www.ipcc.ch/meetings/session31/doc20-rev1.pdf,

PBL, 2009. News in Climate Science and Exploring the Boundaries. http://www.rivm.nl/bibliotheek/rapporten/500114013A.pdf

Part II – Detailed analysis of regional chapters and summaries

This Part presents:

- our findings referring to the foundation for the 32 summary conclusions on regional impacts in the Synthesis Report (see Annex A) – below, these conclusions have been typeset as headers, followed by our findings;
- additional findings at lower levels, such as those referring to the foundations for statements on regional impacts in the Technical Summary and Executive Summaries of the regional chapters, and also some findings on parts of the main text that we came across while working on other findings – below, statements have been typeset as headers, followed by our findings.

For our investigation, we used several criteria for assessing the quality of IPCC statements. First of all, we employed a distinction between obvious factual 'errors' – which we believe require an erratum on the IPCC Fourth Assessment web pages – and 'comments', the latter being critical remarks, made from our specific position of having to assess these statements on behalf of Dutch policymakers. These criteria were developed 'on the job', while categorising our findings. In total, there are nine criteria, and associated with these are two types of 'errors' (E1-E2) and seven types of 'comments' (C1-C7):

- E1: *Inaccuracy of a statement*;
- E2: *Inaccuracy of literature referencing*;
- C1: *Insufficiently substantiated attribution*, when a certain impact had been attributed to climate change without convincing foundation;
- C2: *Insufficiently founded generalisation*, when case studies had been extrapolated to whole regions/sectors without convincing foundation;
- C3: *Insufficiently transparent expert judgment*, when we could not trace the reasoning behind a statement from underlying texts or literature references given;
- C4: *Inconsistency of messages*, when found between the different layers in the IPCC report;
- C5: *Untraceable reference*, when a literature reference could not be found;
- C6: *Unnecessary reliance on grey referencing*, when reference had been made to grey literature (literature other than from peer-reviewed journals), while adequate peer-reviewed scientific journal references would have been available;

- C7: *Statement unavailable for review*, when new information had been introduced after the last review but was not clearly derived from a content issue raised in this last review.

When a certain statement in the IPCC Fourth Assessment Report would meet all the criteria, the statement was considered to be well founded and reliable.

5 Africa

5.1 Analysis of statements in Table SPM.2 of the Synthesis Report

By 2020, between 75 and 250 million of people are projected to be exposed to increased water stress due to climate change. (E1; minor)

This statement was based on Table 11 in a study by Arnell (2004), which contains results on increased water stress by 2025 (instead of 2020) as computed by several climate models for five sub-regions in Africa (and other continents). In our communication with Nigel Arnell, concerning the addition of numbers in the table (which gives a range of between 75 and 240 million people, consistent with the rounded numbers in the statement), he informed us that he had recently noticed that, in this case, the addition of ranges was an unreliable method for determining the total range. For the HADCM3 model the table contains a range of model outcomes from three model runs of the SRES A2 scenario and a range from two model runs of the B2 scenario, but the low and high values did *not* originate from the same model run. Simply adding up these extreme values from the model outcomes for the sub-regions may thus overstate the range. It must be added here that, although this type of error is well known to occur in scientific practice, the IPCC authors, including Nigel Arnell who was a Lead Author of a sectoral chapter (Chapter 3) of the Working Group II Report, considered the straightforward addition of those extreme values appropriate at the time. With the benefit of hindsight, a relatively simple reanalysis of the data would have brought this error to light. According to Arnell (2010), the correct range that results from adding the right numbers for Africa would be: 88 to 217 million people. This implies that 'between 75 and 250 million' should have read 'between 90 and 220 million' when rounded to the nearest 10 (E1b). However, since the difference is only small and uncertainties are considerable, and because the original paper did not provide the details that would have allowed correct computing of this range, we consider this to be a minor inaccuracy.

By 2020, in some countries, yields from rain-fed agriculture could be reduced by up to 50%. (C3,C5,C7; major)

This statement is not directly a statement on climate change, but on climate variability: in individual years, droughts can cause up to 50% in yield reductions. The implicit message here is that when droughts would become more frequent due to climate change, more years with up to 50% in yield reductions would occur. The statement could easily mislead readers into thinking that average annual yields could be reduced by up to 50% due to climate change. In the Summary for Policymakers of the Working Group II Report, the paragraph that contains this

statement starts with a sentence introducing the notion of climate variability, which puts the statement more into context. We have several major comments to make about its provenance. The statement was based on a report by the International Institute for Sustainable Development (IISD) (Agoumi, 2003) that referred to studies performed within the framework of a UNEP–GEF project that we were unable to trace (C5) and to the Initial National Communications (INCs) of Morocco, Algeria and Tunisia. However, only the INC of Morocco (Kingdom of Morocco, 2001) reported a decline in yields for 2020: 'a 50% reduction in cereal yields in Morocco might occur in dry years and 10% in normal years'. The IPCC authors explained to us that present-day climates and projected future climate change in the three countries are very similar – with a reference to Figure 11.2 in the Working Group I Report of AR4 – and also that only cereals are grown without irrigation. Furthermore, using information from the European statistical information service (EUROSTAT) the authors made plausible that, due to current climate variability, the yields in Algeria, Morocco and Tunisia have been varying annually, including yield reductions of nearly 70% in individual years, in the period between 2000 and 2006. In hindsight, these additional explanations could have provided further foundations for the statement, had they been included in Chapter 9 (C3).

The Initial National Communication of Morocco indicated that this statement was based on 'The Study of Morocco's Vulnerability to CC Effects' (MATUHE, 2001). However, we were unable to trace this study, nor could it be provided by the IPCC authors (C5). Although the IPCC does not formally require that authors check references of references of references, it would have been very helpful in this case; the IPCC requires that the chapter team reviews the quality and validity of non-peer-reviewed sources (C5). As it stands, the statement cannot be traced back to any original scientific research.

Finally, the statement seemed to have been added to the main text of Chapter 9 after the Second Order Draft had been reviewed, but we were unable to find the particular substantive comment(s) made in this review that could have led to the addition of this statement (C7).

Agricultural production, including access to food, in many African countries is projected to be severely compromised. This would further adversely affect food security and exacerbate malnutrition.

This statement – which together with the previous statement comprises the second bulleted statement on Africa in Table SPM.2 (see Annex A) – is fully supported by the underlying material.

Towards the end of the 21st century, projected sea level rise will affect low-lying coastal areas with large populations. The cost of adaptation could amount to at least 5 to 10% of Gross Domestic Product (GDP). (C3; minor)

The first sentence of this statement is fully supported by the underlying material. We have a comment to make about the second sentence of the statement, which was based on a table in a study by Niang-Diop (2005). The text does not explicate how the experts derived the 5 to 10% in adaptation costs from this study, since it covered a range from 0.5 to 156.2% (C3). The IPCC authors explained to us that they used 5 of 12 studies summarised in the table in Niang-Diop (2005). Those that

scored below the range of 5 to 10% were either countries that did an assessment not covering the entire country (Cameroon: 0.5%; Gambia: 1%), or those with a very short coastline (Democratic Republic of the Congo: 4.1%), or relatively rich countries (Nigeria: 2.2%). Those that scored well above this range were either very small island states (Comoros: 49.7%) or countries for which the costs had been overestimated (Mauritania: 156.2%). This answer explains the 5 to 10% range. We believe it would have been helpful if this explanation had been provided in Chapter 9.

By 2080, an increase of 5 to 8% of arid and semi-arid land in Africa is projected under a range of climate scenarios.
This statement is fully supported by the underlying material.

5.2 Additional findings

The population at risk of increased water stress in Africa is projected to be between 75–250 million and 350–600 million people by the 2020s and 2050s, respectively (E1; minor).
This statement is part of the Executive Summary and is also included in Table TS.4 on page 67 of the Technical Summary. The range of 75 to 250 million people is discussed above in Section 5.1 (first statement). From Nigel Arnell, the author of the underlying 2004 study, we learned that also the second range (350 to 600 million people in the 2050s) was incorrectly computed from Table 11 in his study; the extreme values for the sub-regions cannot be added together. This remained unnoticed during the writing of the Working Group II Report. According to Arnell, in hindsight, the correct range should have been 350 to 490 million (E1b). Given the large uncertainties, we consider this a minor error. This inaccuracy has no impact on the IPCC conclusions in the various Summaries for Policymakers.

In South Africa, fisheries could be affected [...]. Recent simulations based on the NCAR GCM under a doubling of carbon dioxide indicate that extreme wind and turbulence could decrease productivity by 50-60%, while turbulence will probably bring about a 10% decline in productivity in the spawning grounds and an increase of 3% in the main feeding grounds. (E1; major)
This statement originates from Section 9.4.4 of the main text, and was based on a study by Clark et al. (2003), which indicated that the changes in the *frequency of extreme wind and turbulence events* is expected to decrease quite substantially, by 50 to 60%; it did not refer to a similar decrease in fishery *productivity* (E1a). Also, in the latter part of the sentence it should have been the changes in *mean turbulence* that decline by 10% and increase by 3%, and not the productivity. The IPCC authors initially indicated that the reference to 'productivity' should have been deleted and *'for anchovy'* should have been added at the end. In that case, the statement would read as follows:

Recent simulations based on the NCAR GCM under a doubling of carbon dioxide indicate that the frequency of extreme wind and turbulence events could decrease by 50 to 60%, while mean turbulence will probably decline by 10% in the spawning grounds and increase by 3% in the main feeding grounds for anchovy.

From the IPCC authors we received the following proposal for an erratum:

Recent simulations based on the NCAR GCM under a doubling of carbon dioxide indicate that changes in extreme wind and turbulence could decrease potential spawning and increase potential larval feeding of anchovy.

This major error has no impact on the IPCC conclusions in the various Summaries for Policymakers.

5.3 Findings from the PBL registration website

Agricultural intensification and/or expansion into marginal lands can trigger additional conflicts, cause crop failure, exacerbate environmental degradation (e.g., Olsson et al., 2005). (minor)

This statement can be found on page 441, Section 9.2.2.4, of the main text. One of the reactions we received on the registration website indicated that the reference to Olsson et al. (2005) in relation to this particular statement is not the most relevant one, because the article does not focus primarily on the intensification and/or expansion of agriculture and its consequences. Olsson et al. (2005) is about changes in precipitation patterns that have resulted in the greening of the Sahel over the past 10 years (5 years at the time of writing). We believe that other, more appropriate references would have been available for this statement, but we have not assigned this less appropriate referencing to one of our qualification categories. It has no impact on the IPCC conclusions in the various Summaries for Policymakers.

In the Sahelian region of Africa, warmer and drier conditions have led to a reduced length of growing season with detrimental effects on crops. (major)

This statement was taken from page 9 of the Summary for Policymakers of the Working Group II Report. One of the reactions we received indicated that this summary statement did not adequately convey the nuances contained in Chapter 9.[1)] In response to that reaction, we wish to make a major comment on this statement. It was based on two sentences in Section 1.3.6.1 of the main text: *'In Sahelian countries, increasing temperature in combination with rainfall reduction has led to a reduced length of vegetative period, no longer allowing present varieties to complete their cycle (Ben Mohamed et al., 2002).'* and: *'In the case of the Sahel region of Africa, warmer and drier conditions have served as a catalyst for a number of other factors that have accelerated a decline in groundnut production (Van Duivenbooden et al., 2002).'* Even though the statement does not directly refer to the regional chapters, it is a statement in the Summary for Policymakers on a regional impact.

Although, the Summary for Policymakers' text is consistent with the formulations in the main text, we believe that the subject of both case studies, which deal with millet, groundnut and cowpeas in Niger, cannot be generalised to describe *'the Sahelian region'* and to *'effects on crops'*. In reaction to this, the IPCC authors replied that '*the Sahelian region'* is not the same as '*the entire Sahelian region'* and '*effects on*

1) This reaction and the previous one were received as one combined reaction; in our report we treat them separately, since they pertain to different statements.

crops' is not the same as '*effects on all crops*'. In addition, the authors have pointed to the heading of this section (p. 9, Working Group II Summary for Policymakers) that says these are 'examples' and 'have not yet become established trends'. The authors further commented that these are obviously not universal statements. In their opinion, it would be unnecessary for every statement on certain parts of a place or region to say 'parts of', and similarly about statements on systems to say 'some of', because in their view this non-universality is implicit.

Indeed, the disclaimer in the header does explain that these are examples and not established trends, but to us it is not obvious that the statement therefore refers to *some* crops in a *part of,* for instance, the Sahelian region, and we believe it would have been better if these specifications had been added. This major comment has no consequences for the IPCC conclusions in the various Summaries for Policymakers.

References

Agoumi, A., 2003. Vulnerability of North African countries to climatic changes: adaptation and implementation strategies for climatic change. Developing Perspectives on Climate Change: Issues and Analysis from Developing Countries and Countries with Economies in Transition. IISD/ Climate Change Knowledge Network, 14 pp. http://www.cckn.net//pdf/north_africa.pdf

Arnell, N.W., 2004. Climate change and global water resources: SRES emissions and socio-economic scenarios. Global Environ. Change, 14, 31-52.

Arnell, N.W., 2010. Personal communication.

Ben Mohamed A., Duivenbooden, N. van, Abdoussalam, S., 2002, Impact of climate change on agricultural production in the Sahel- part I. methodological approach and case study for millet in Niger, Climatic Change, 54, pg 327-348.

Clark, B.M., S. Young and A. Richardson, 2003. Likely effects of global climate change on the purse seine fishery for Cape anchovy Engraulis capensis off the west coast of Southern Africa (SE Atlantic). http://swfsc.noaa.gov/uploadedFiles/Education/lasker_events.doc.

Van Drunen, M.A., R. Lasage and C. Dorland, Eds., 2005. Climate Change in Developing Countries: An Overview of Study Results from the Netherlands Climate Change Studies Assistance Programme. CABI Publishing,Amsterdam, 320 pp.

Duivenbooden, N. van, Abdoussalam, S., Ben Mohamed A., 2002. Impact of climate change on agricultural production in the Sahel- part II> Cae study for groundnut and cowpea in Niger, Climatic Change, 54, pg 349-368.

Kingdom of Morocco, 2001. Initial National Communication on the United Nations Framework Convention on Climate Change, Ministry of Land-use Planning, Housing, and the Environment, October. http://unfccc.int/resource/docs/natc/mornc1e.pdf

MATUHE, 2001. Etude de Vulnérabilité du Royaume du Maroc face aux impacts des changements climatiques. Ministère chargé de l'Aménagement du Territoire, de l'Urbanisme, del'Habitat et de l'Environnement, septembre 2001.

Niang-Diop, I., 2005. Impacts of climate change on the coastal zones of Africa. Coastal Zones in Sub-Saharan Africa: A Scientific Review of the Priority Issues Influencing Sustainability and Vulnerability in Coastal Communities, IOC, Ed., IOCWorkshop Report No. 186. ICAM Dossier No. 4, 27-33.

Olsson, L., Eklundh, L., Ardö, J., 2005. A recent greening of the Sahel—trends, patterns and potential causes. Journal of Arid Environments, 63, pg 556–566.

Otter, L., Olago, D.O. and Niang, I. (eds), 2007. Global Change Processes and Impacts in Africa: A Synthesis. START/East African Educational Publishers, Nairobi. 346 pages. September 2007.

Asia

6

6.1 Analysis of statements in Table SPM.2 of the Synthesis Report

By the 2050s, freshwater availability in Central, South, East and South-East Asia, particularly in large river basins, is projected to decrease. (C2,C3; major)
This statement originates from the Executive Summary of Chapter 10 of the main text. Section 10.4.2 of the main text does not clearly reveal projections indicating an absolute decrease in freshwater availability in all indicated areas by the 2050s. There is no indication of how freshwater availability should be interpreted in this statement, that is, whether it concerns absolute flows or per-capita availability, which makes it hard to establish the line of reasoning that was followed, since a combination of evidence using different metrics has been cited in the chapter (C3). In the main chapter text, there are various referenced projections of 'water stress' (availability relative to demand) for South and Southeast Asia by 2050, projections of reduced run-off in mid-China by the end of the 21st century, and reductions in the *per-capita* availability of fresh water in India by 2050. There is a reference to a region in Central Asia (Hindu-Kush) and its dependence on meltwater from glaciers, but no long-term projections are given. However, according to model calculations, the runoff projections for 2100 in the sectoral Chapter 3 ('Freshwater resources and their management') show an *increase* in annual runoff in South, East and Southeast Asia (Figure 3.8, on page 201). This, of course, does not contradict possible severe water stress during dry seasons, but neither does it support the generalisation that led to the statement in the Summary for Policymakers (C2).

Coastal areas, especially heavily populated megadelta regions in South, East and South-East Asia, will be at greatest risk due to increased flooding from the sea and, in some megadeltas, flooding from the rivers.
This statement is fully supported by the underlying material.

Climate change is projected to compound the pressures on natural resources and the environment associated with rapid urbanisation, industrialisation and economic development.
This statement is fully supported by the underlying material.

Endemic morbidity and mortality due to diarrhoeal disease primarily associated with floods and droughts are expected to rise in East, South and South-East Asia due to projected changes in the hydrological cycle. (C3; minor)
This statement is fully supported by the underlying material.

6.2 Additional findings

The already discovered error on the melting rate of glaciers (Section 10.6.2 of the main text) is treated in Annex B.

The frequency and extent of forest fires in northern Asia is expected to increase in the future due to climate change and extreme weather events that could likely limit forest expansion. (C3,C6; major)

See the Executive Summary, page 471, the Technical Summary, pages 49, and Box TS.6 on page 60. We have a comment to make on this statement. In the underlying text, nuances and uncertainties are clearly described: *'The observations in the past 20 years show that the increasing intensity and spread of forest fires in North and South-East Asia were largely related to rises in temperature and declines in precipitation in combination with increasing intensity of land uses (see Section 10.2.4.4). Whether this trend will persist in the future or not is difficult to ascertain in view of the limited literature on how the frequency and severity of forest and brush fires will likely respond to expected increase in temperature and precipitation in North and South-East Asia (see Section 10.3.1).'* In the text, the expected future increase was solely underpinned by a reference to a single conference paper, which was based on a speech by the Vice-Minister of the Ministry of the Russian Federation for Civil Defence and did not include any references (Vorobyov, 2004). Given the response by the authors that the statement is an adequate reflection of other literature not listed in the chapter, we concluded that the statement is an insufficiently transparent expert judgment (C3) and that the referencing was unnecessarily relying on grey literature (C6). The IPCC authors explained to us the policy relevance of including this statement in the Executive Summary of the chapter and in the Technical Summary. Even though the research in this area was in an early stage and the modelling of future impacts was limited in 2006, the authors considered this subject to be sufficiently important because of its potential scale of effect. The statement was awarded only medium confidence (having an even chance of being correct), but given the use of the word 'likely', we think it could have been worded more carefully. These major comments have no consequences for the IPCC conclusions in the various Summaries for Policymakers.

Recent risk analysis of coral reef suggests that between 24% and 30% of the reefs in Asia are likely to be lost during the next 10 years and 30 years, respectively. (E2; minor)

For this statement, see the Executive Summary, page 471, and the Technical Summary, Box TS.6 on page 59. We identified an inaccurate reference affecting this statement. The statement cannot be deduced from the figures presented in the included table (Table 10.6). Also, the underlying reference (Wilkinson, 2004) does not provide information to support the statement. The IPCC authors indicated that (Wilkinson, 2004) was cited incorrectly; this should have been (Wilkinson, 2000) (E2). This minor inaccuracy has no impact on the IPCC conclusions in the various Summaries for Policymakers.

The Third Assessment Report (TAR) predicted that the area-averaged annual mean warming would be about 3°C in the decade of the 2050s and about 5°C in the decade of the 2080s over the land regions of Asia as a result of future increases in atmospheric concentration of greenhouse gases (Lal et al., 2001a). (minor).

For this statement, see Section 10.1.1 of the main text, page 471. We have one minor comment to make on this statement (which could not be placed in one of the categories). In the First Order Draft, the statement used the word 'reported' instead of 'predicted, and one of the comments in the review of the First Order Draft was that 'The TAR reported that...' should be changed to 'The TAR predicted that...' or 'The TAR forecasted that...'. This comment was responded to, saying that 'IPCC Assessment Reports do not predict or forecast – they only report', however, the sentence was changed nevertheless to 'The TAR predicted that…'. It may be useful to note that in the IPCC reports, normally, the verb 'to project' is used instead of 'to predict' to denote the fact that a statement is made relative to a particular scenario. A comment on the Second Order Draft, made by the Republic of Korea, was to 'specify the SRES scenario used for this assessment statement'. This comment was accepted according to the authors' response ('Appropriate revisions and editing made'), but no changes were implemented in the final texts. This minor comment has no consequences for the IPCC conclusions in the various Summaries for Policymakers.

References

Vorobyov,Y., 2004. Climate change and disasters in Russia. Proc. World Climate Change Conference, Moscow, Y. Izrael, G. Gruza, S. Semenov and I. Nazarov, Eds., Institute of Global Climate and Ecology, Moscow, 293-298.

Wilkinson, C., Ed., 2000. Status of Coral Reefs of the World: 2000.Australian Institute of Marine Science, Townsville, 363 pp.

Wilkinson, C., Ed., 2004. Status of Coral Reefs of the World: 2004, Volume 1. Australian Institute of Marine Science, Townsville, 302 pp.

Australia and New Zealand

7

7.1 Analysis of statements in Table SPM.2 of the Synthesis Report

By 2020, significant loss of biodiversity is projected to occur in some ecologically rich sites, including the Great Barrier Reef and Queensland Wet Tropics. (E2,C3; minor)

In the text of Chapter 11 of the Working Group II Report, which underpins the statement, we found an inaccurate reference. Biodiversity loss on the Great Barrier Reef is covered by Table 11.6, in which is stated, for 2020: '*Bleaching and damage to the Great Barrier Reef equivalent to that in 1998 and 2002 in up to 50% of years. (Berkelmans et al., 2004; Crimp et al., 2004)* and *60% of the Great Barrier Reef regularly bleached (Jones, 2004b).'* The references for the first and second statement are not correct (E2). The IPCC authors indicated that the correct reference for both statements is Sheehan et al. (2006).

Furthermore, we were unable to derive the statements in Table 11.6 from the provided, correct reference (Sheehan et al, 2006). The reference relates impacts to temperature changes, not to specific years, which in this case would have been 2020. Implicitly, the IPCC authors converted warming into years by using Table 11.4, that is, a near-coast warming in the range of 0.1 to 1.0 °C by 2020. As also confirmed by the IPCC authors, this conversion should have been explicitly stated in the caption of Table 11.6 (C3). We consider this to be a minor comment.

By 2030, water security problems are projected to intensify in southern and eastern Australia and, in New Zealand, in Northland and some eastern regions.

This statement is fully supported by the underlying material.

By 2030, production from agriculture and forestry is projected to decline over much of southern and eastern Australia, and over parts of eastern New Zealand, due to increased drought and fire. However, in New Zealand, initial benefits are projected in some other regions.

This statement is fully supported by the underlying material.

By 2050, ongoing coastal development and population growth in some areas of Australia and New Zealand are projected to exacerbate risks from sea level rise and increases in the severity and frequency of storms and coastal flooding.

This statement is fully supported by the underlying material.

7.2 Additional findings

3,000 to 5,000 more heat related deaths per year. (C1; major)

This example of regional impact was taken from Table TS.4 of the Technical Summary. We have a major comment to make on this statement.

From Table TS.4 readers may mistakenly conclude that 3,000 to 5,000 more heat-related deaths could be directly attributed to temperature change (as is the case with the 'additional people suffering from increased water stress' also shown in the table). However, the largest part of the 3,000–5,000 range is dependent on expected changes in population sizes and age distributions within cities (C1). With the other drivers remaining constant, temperature change would only be responsible for 300 to 900 more heat-related deaths (this can be calculated from Table 2 in McMichael et al., 2003). This is only a small part of the 3,000 to 5,000 more heat-related deaths mentioned in the table. The underpinning for the statement in Table TS.4 is given in Section 11.4.11 on health. The relevant sentence is: *'Assuming no planned adaptation, the number of deaths is likely to rise from 1,115/yr at present in Adelaide, Melbourne, Perth, Sydney and Brisbane to 2,300 to 2,500/yr by 2020, and 4,300 to 6,300/yr by 2050, for all SRES scenarios, including demographic change (McMichael et al., 2003)'.* The stated numbers include both demographic and temperature effects. In the chapter is not mentioned that the effect of temperature change alone is relatively small, compared to the combined effect of temperature change and changes in population sizes and age distributions.

We believe that the total number of heat-related deaths by 2050 (3,000–5,000) is a number that IPCC should publish, as policymakers should be made aware of *all* heat-related deaths, not just those due to climate change. However, it is also our opinion that an IPCC report on climate-change impacts should show the different components including the climate-change related component, if available or traceable. It is no easy matter to establish a climate-change related component, but one way of doing this would be to make a comparison between changes in the demographic situation of 2050 with climate change and without. A simple calculation performed by the PBL resulted in 1,000 to 3,000 additional heat-related death per year, as a consequence of climate change, which is significantly less than the 3,000 to 5,000 range given in Table TS.4. This major comment has no consequences for the IPCC conclusions in the various Summaries for Policymakers.

Heat waves and fires are virtually certain to increase in intensity and frequency. (C4; minor)

This statement originates from the Executive Summary. We have a minor comment to make on this statement. In our opinion, there is an inconsistency between the level of likelihood in the Executive Summary and in the chapter text. The relevant chapter text in Section 11.3.1 repeatedly uses 'likely' for increases related to fires, and it not clear why 'likely' was subsequently translated to 'virtually certain' in the Executive Summary (C4). The IPCC authors have concluded, after consultation with authors of relevant references, that the likelihoods in the chapter may have been understated. This minor comment has no consequences for the IPCC conclusions in the various Summaries for Policymakers.

Since 1950 there has been a 0.3 to 0.7 °C warming in the region. (E1; minor)

This statement, taken from the Technical Summary on page 50, is different from the Executive Summary, which states: '*Since 1950, there has been 0.4 to 0.7°C warming,...*'. This is a minor inaccuracy (E1a). The authors confirmed this to be a typographical error in the Technical Summary; 0.4 °C is the correct number. This minor inaccuracy has no impact on the IPCC conclusions in the various Summaries for Policymakers.

References

Berkelmans, R., G. De'ath, S. Kininmonth and W.J. Skirving, 2004. A comparison of the 1998 and 2002 coral bleaching events of the Great Barrier Reef: spatial correlation, patterns and predictions. Coral Reefs, 23, 74-83.

Crimp, S., J. Balston, A. Ash, L. Anderson-Berry, T. Done, R. Greiner, D. Jones, R.N., 2004b. Managing climate change risks. The Benefits of Climate Policies: Analytical and Framework Issues, J. Corfee Morlot and S. Agrawala, Eds., OECD, 251-297. http://www.oecd.org/document/35/0,2340,en_ 2649_34361_ 34086819_1_1_1_1,00.html.

McMichael, A., R. Woodruff, P. Whetton, K. Hennessy, N. Nicholls, S. Hales, A. Woodward and T. Kjellstrom, 2003. Human Health and Climate Change in Oceania: A Risk Assessment 2002. Commonwealth Department of Health and Ageing, 128 pp. http://www.health.gov.au/internet/main/publishing.nsf/Content/2D4037B384BC05F6CA256F1900042840/$File/env_climate.pdf

Sheehan, P., R. Jones, A. Jolley, B.L. Preston, M. Clark, P.J. Durack, S. Islam, F.Sun, and P.H. Whetton, 2006. Climate Change and the Global Knowledge Economy: An Immediate Challenge. CSES Climate Change Working Paper No. 11. Victoria University Centre for Strategic Economic Studies, Melbourne, 35 pp. http://www.cfses.com/documents/climate/11_Sheehan_Jones_et_al_Climate_Change_.pdf

Europe

8

8.1 Analysis of statements in Table SPM.2 of the Synthesis Report

Climate change is expected to magnify regional differences in Europe's natural resources and assets. Negative impacts will include increased risk of inland flash floods and more frequent coastal flooding and increased erosion (due to storminess and sea level rise).
This statement is fully supported by the underlying material.

Mountainous areas will face glacier retreat, reduced snow cover and winter tourism, and extensive species losses (in some areas up to 60% under high emissions scenarios by 2080). (C3; minor)
We have one minor comment to make on this statement (which is also included, verbatim, in the Summary for Policymakers of the Working Group II Report). The Executive Summary only addresses extensive species loss in 'mountain *plant* communities, which face a loss in species of up to 60% under high emission scenarios', but *does not mention mountain fauna*, nor does Thuiller et al. (2005), the publication on which the example was based. Thus, the example given in the statement in the Summary for Policymakers ('in some areas up to 60%...') was not fully derived from the text in the Executive Summary or from the main text of Chapter 12. In addition, it is not transparent how the authors have underpinned the example (C3). After an additional literature search on our part, it appeared that there was a reference that the authors could have used for underpinning the example. A report by the Potsdam Institute for Climate Impact Research (PIK) (Schröter et al., 2004) that was not included in the references of the chapter, explicitly presented quantitative results which refer to species loss in mountain flora and fauna of up to 60% (Figure 25 in Schröter et al., 2004). We judged this omission of a reference and of a more traceable line of reasoning from the chapter to the Summary for Policymakers to be of minor effect.

In southern Europe, climate change is projected to worsen conditions (high temperatures and drought) in a region already vulnerable to climate variability, and to reduce water availability, hydropower potential, summer tourism and, in general, crop productivity.
This statement is fully supported by the underlying material.

Climate change is also projected to increase the health risks due to heat waves and the frequency of wildfires.
This statement is fully supported by the underlying material.

8.2 Additional findings

The already discovered error on the Dutch land area below sea level (in the main text of Chapter 12, on page 547) is discussed in Annex C.

Adaptation to climate change is likely to benefit from experiences gained in reactions to extreme climate events, by specifically implementing proactive climate-change risk management adaptation plans (very high confidence). (C4; minor)
This statement appears in the Technical Summary (page 53) and in the Summary for Policymakers of the Working Group II Report (page 14). However, the exact same statement received a lower confidence level ('high confidence') in the Executive Summary (page 543) (C4). The IPCC authors replied that the correct level of confidence should have been 'very high confidence' This was an editorial mistake; IPCC has indicated that it will issue an erratum. This minor inconsistency has no impact on the IPCC conclusions in the Summary for Policymakers of the Synthesis Report.

In southern Europe, general decreases in yield (e.g., legumes -30 to +5%; sunflower -12 to +3% and tuber crops -14 to +7% by 2050) and increases in water demand (e.g., for maize +2 to +4% and potato +6 to +10% by 2050) are expected for spring sown crops (Giannokopoulos et al., 2005; Audsley et al., 2006). (E1; minor)
The statement, which was taken from the main text of Chapter 12 (page 555), is slightly inaccurate (E1a). In Giannokopoulos et al. (2005), four Mediterranean regions have been distinguished. Only two are located in Europe (those labelled 'N-W' and 'N-E'). The numbers (ranges) presented in the IPCC Working Group II Report refer to all four regions, including North Africa, Jordan, Libya and Egypt, and should not have been reported in the chapter on Europe. The correct ranges for the European regions should read: Legumes (beans/soybean) -14 % to +1 %; C3 (sunflower) -12% to + 1%; and Tubers (potato) -9% to +8 %). The IPCC authors have told us that this finding will lead to an IPCC erratum. These minor inaccuracies have no impact on the IPCC conclusions in the various Summaries for Policymakers.

Annual average runoff is projected to increase *in northern Europe* (north of 47°N) by approximately *5 to 15% up to the 2020s and 9 to 22% up to the 2070s*, for the SRES A2 and B2 scenarios and climate scenarios from two different climate models (Alcamo et al., 2007) (Figure 12.1). Meanwhile, *in southern Europe (south of 47°N), runoff decreases by 0 to 23% up to the 2020s and by 6 to 36% up to the 2070s* (for the same set of assumptions). (C3; minor)
We have a minor comment to make on this statement. The quantitative information in this statement (Chapter 12, page 549), as well as in Figure 12.1, could not be found in the specific paper cited (Alcamo et al., 2007) (C3). In a reaction, the IPCC authors responded by saying that – for the accomplishment of the most up-to-date review of scientific knowledge – they sometimes also used underlying data that had formed the basis of the results in the peer-reviewed publications; they obtained this background data by contacting the authors of these publications and asking for specific figures. Our comment does not imply that such information should not be used, but only that the provenance of this information could have been made more transparent. This minor comment has no consequences for the IPCC conclusions in the various Summaries for Policymakers.

Climate-related increases in crop yields are expected mainly in northern Europe, e.g., wheat: +2 to +9% by 2020, +8 to +25% by 2050, +10 to +30% by 2080 (Alexandrov et al., 2002; Ewert et al., 2005; Audsley et al., 2006; Olesen et al., 2007), and sugar beet +14 to +20% until the 2050s in England and Wales (Richter and Semenov, 2005),... The impacts on autumn sown crops are more geographically variable; yield is expected to strongly decrease in most southern areas, and increase in northern or cooler areas (e.g., *wheat: +3 to +4% by 2020, -8 to +22% by 2050, -15 to +32% by 2080*) (Santos et al., 2002; Giannakopoulos et al., 2005; Audsley et al., 2006; Olesen et al., 2007). (C3; minor)

We have a minor comment to make on this statement. It is not transparent how the quantitative information on wheat yield and sugar beet as presented in this statement (Chapter 12, page 555) was derived from the numbers given in the cited references (C3). The IPCC authors explained to us in more detail how these numbers had been established on the basis of the cited references. Although we have no reason to doubt the correct underpinning of these results, we do think that the provenance of presented quantitative information in IPCC reports – if it cannot be derived from the cited references – should be clearly explained for reasons of transparency and traceability. This minor comment has no consequences for the IPCC conclusions in the various Summaries for Policymakers.

However, on balance health risks are very likely to increase (C3; major)

We have a major comment to make on this statement, which was taken from the Executive Summary (page 543) and summarises the IPCC authors' expert judgment on the balance between positive and negative effects of climate change on health. Supportive material is presented in the main text (see e.g. Section 12.4.11 on pages 557–558; Figure 12.3 on page 558; Table 12.1 on page 546, and Table 12.4 on page 565), which also provides a more regionally differentiated picture. However, a quantitative underpinning for the statement is lacking in the main text (C3).

The IPCC authors indicated to us that they weighed the positive and negative effects and this was their final assessment. Pages 557 to 558 of Chapter 12 give a detailed account of all impacts, and we found the negative impacts to be the norm, not the positive ones. However, although the list of negative effects is longer, no indication of their relative weights is given, which makes the expert judgment about the 'balance' in our view insufficiently transparent.

Although the statement was not included in the various Summaries for Policymakers, many readers may consider it to be highly policy relevant.

This major comment has no consequences for the IPCC conclusions in the various Summaries for Policymakers.

8.3 Findings from the PBL registration website

For the first time, wide-ranging impacts of changes in current climate have been documented: retreating glaciers, longer growing seasons, shift of species ranges, and health impacts due to a heat wave of unprecedented magnitude. (minor)

We received a reaction to this statement which criticised the presenting of the 2003 heat wave as a consequence of climate change. In response to that reaction, we wish to make a minor comment on this statement (although it does not fit one of our qualification categories). The Working Group II Summary for Policymakers states, for Europe, on page 14: *'For the first time, wide-ranging impacts of changes in current climate have been documented: retreating glaciers, longer growing seasons, shift of species ranges, and health impacts due to a heat wave of unprecedented magnitude. The observed changes described above are consistent with those projected for future climate change.'* This text, as well as its counterparts in Table TS4.2 of the Technical Summary (page 51) and in the Executive Summary (page 543), present the health impacts from the 2003 heat wave as an example of 'wide-ranging impact of changes in current climate'. Thus, the text implicitly suggests that the 2003 heat wave is the result of recent climate change. However, one can never attribute a specific extreme weather event of the past – such as that particular heat wave –to changes in current climate. In fact, Schär and Jendritzky (2004) concluded: *'The European heatwave of 2003: was it merely a rare meteorological event or a first glimpse of climate change to come? Probably both.'* The IPCC authors have indicated that the statement in the Summary for Policymakers does not contain a formal attribution – otherwise, the second sentence 'the observed changes described above are consistent with those projected for future climate change' would not have been necessary; the authors' reaction is factually correct, but the wording remains suggestive in our view. Chapter 1 of the Working Group II Report contains statements that are more careful, assessing the evidence of observed increases in heat waves in Europe. This minor comment has no consequences for the Summary for Policymakers of the Synthesis Report.

References

Alcamo, J., M. Floerke and M. Maerker, 2007. Future long-term changes in global water resources driven by socio-economic and climatic changes. Hydrological Sciences, 52, 247-275.

Alexandrov, V., J. Eitzinger, V. Cajic and M. Oberforster, 2002. Potential impact of climate change on selected agricultural crops in north-eastern Austria. Glob. Change Biol., 8, 372-389.

Audsley, E., K.R. Pearn, C. Simota, G. Cojocaru, E. Koutsidou, M.D.A. Rounsevell, M. Trnka and V. Alexandrov, 2006. What can scenario modelling tell us about future European scale agricultural land use, and what not? Environ. Sci. Pol., 9, 148-162.

Ewert, F., M.D.A. Rounsevell, I. Reginster, M.J. Metzger and R. Leemans, 2005. Future scenarios of European agricultural land use I. Estimating changes in crop productivity. Agr. Ecosyst. Environ., 107, 101-116.

Giannakopoulos, C., M. Bindi, M. Moriondo, P. LeSager and T. Tin, 2005. Climate Change Impacts in the Mediterranean Resulting from a 20C Global Temperature Rise. WWF report, Gland Switzerland. Accessed 01.10.2006 at http://assets.panda.org/downloads/medreportfinal8july05.pdf.

Olesen, J.E., T.R. Carter, C.H. Díaz-Ambrona, S. Fronzek, T. Heidmann, T. Hickler, T. Holt, M.I. Mínguez, P. Morales, J. Palutikhof, M. Quemada, M. Ruiz-Ramos, G. Rubaek, F. Sau, B. Smith and M. Sykes, 2007: Uncertainties in projected impacts of climate change on European agriculture and terrestrial ecosystems based on scenarios from regional climate models. Climatic Change, 81, S123-S143.

Richter, G. and M. Semenov, 2005: Re-assessing drought risks for UK corps using UKCIP02 climate change scenarios. Final report of Defra project CC0368.

Schär, C. and G. Jendritzky, 2004: Climate change: hot news from summer 2003. Nature, 432, 559-560.

Schröter, D., et al., 2004. Advanced Terrestrial Ecosystem Analysis and Modelling (ATEAM): Final Report 2004. Section 5 and 6 and Annex 1 to 6. Accessed 22-4-2010 at http://www.pik-potsdam.de/ateam/ateam_final_report_sections_5_to_6.pdf.

Santos, F.D., K. Forbes, and R. Moita, Eds., 2002: Climate change in Portugal: scenarios, impacts and adaptation measures. SIAM project report, Gradiva, Lisbon, 456 pp.

Thuiller, W., S. Lavorel, M.B. Araújo, M.T. Sykes and I.C. Prentice, 2005: Climate change threats plant diversity in Europe. Proc. Natl. Acad. Sci. U.S.A., 102, 8245-8250.

Latin America

9

9.1 Analysis of statements in Table SPM.2 of the Synthesis report

By mid century, increases in temperature and associated decreases in soil water are projected to lead to gradual replacement of tropical forest by savanna in eastern Amazonia. Semi-arid vegetation will tend to be replaced by arid-land vegetation.
This statement is fully supported by the underlying material.

There is a risk of significant biodiversity loss through species extinction in many areas of tropical Latin America.
This statement is fully supported by the underlying material.

Productivity of some important crops is projected to decrease (a) and livestock productivity to decline (b), with adverse consequences for food security. In temperate zones, soybean yields are projected to increase (c). Overall, the number of people at risk of hunger is projected to increase (d). (C2; major)
We subdivided this statement by inserting (a) to (d) between issues. We have one comment to make on part (b).

Part (a) (*Productivity of some important crops is projected to decrease*) This is fully supported by the underlying material.

Part (b) (*Livestock productivity is projected to decline*). The 'livestock' appears to be limited to 'cattle' and this part of the statement is underpinned by references to studies on Bolivia and central Argentina. The generalisation to other livestock, which would include pigs, poultry, small ruminants and other animals (together also comprising a substantial fraction of livestock production in Latin America) and to the whole of Latin America, is not underpinned in Chapter 13. We therefore believe that this is an 'insufficiently founded generalisation' (C2).

Statement (c) (*In temperate zones, soybean yields are projected to increase*). This is fully supported by the underlying material.

Statement (d) (*The number of people at risk of hunger is projected to increase*). This is fully supported by the underlying material.

Changes in precipitation patterns and the disappearance of glaciers are projected to significantly affect water availability for human consumption, agriculture and energy generation.
This statement is fully supported by the underlying material.

9.2 Additional findings

Table 13.6 Net increases in the number of people living in water-stressed watersheds. (E1; minor)

Table 13.6 (on page 598 of Chapter 13) combines the *absolute* number of people that live under water-stressed conditions (for the non-climate cases, columns 2, 3 and 5) with the number of people that experience an *increase* in water stress due to climate change (Arnell, 2004). The table's caption, however, suggests all numbers are increases, but this is not correct (E1a). This issue also had been recognised by the IPCC authors, who have indicated to us that they intend to have an erratum issued. Note that we consider this to be a minor inaccuracy and that we have no comment to make about the table's content. This minor inaccuracy has no impact on the IPCC conclusions in the various Summaries for Policymakers.

...the frequency of occurrence of weather and climate extremes is likely to increase in the future; as is the frequency and intensity of hurricanes in the Caribbean Basin. (E1; minor)

This statement was taken from the Executive Summary of Chapter 13, page 583, right column, second paragraph. The statement contains a minor inaccuracy. The Technical Summary of the Working Group I 2007 Report (p. 74) states: *'A synthesis of the model results to date indicates, for a warmer future climate, increased peak wind intensities and increased mean and peak precipitation intensities in future tropical cyclones, with the possibility of a decrease in the number of relatively weak hurricanes, and increased numbers of intense hurricanes. However, the total number of tropical cyclones globally is projected to decrease'.* We conclude that 'frequency and intensity of hurricanes' should have read 'frequency and intensity of *strong* hurricanes' (E1a). This minor inaccuracy has no impact on the IPCC conclusions in the various Summaries for Policymakers.

Up to 40% of the Amazonian forests could react drastically to even a slight reduction in precipitation; this means that the tropical vegetation, hydrology and climate system in South America could change very rapidly to another steady state. (C6; minor)

We have a minor comment to make on this statement, which originates from Section 13.4.1 of Chapter 13 (page 596). The statement was based on Rowell and Moore (2000), which is a peer-reviewed report by the World Wide Fund for Nature and the International Union for Conservation of Nature (WWF/IUCN) on a global review of forest fires, and not a study on changes in vegetation due to climate change. That report, in turn, was mainly based on Nepstad et al. (1999) (in *Nature*). In our opinion, both documents were not the most obvious choice of reference in this case, as their focus is on forest fires (and logging). More adequate peer-reviewed, scientific journal literature would have been available to support this statement, such as Cox et al. (2000; 2004) (C6). This minor comment has no consequences for the IPCC conclusions in the various Summaries for Policymakers.

...some plants will become locally extinct because the elevation range would not permit natural adaptation to temperature increase (FAO, 2002). (C5; minor)

This statement originates from Section 13.4.1 of Chapter 13 (page 596, right column). We were unable to trace FAO (2002) and the URL in the references does

not provide a link to the FAO website (C5). This issue also has been recognised by the IPCC authors, who have indicated that they intend to have an erratum issued. This minor comment has no consequences for the IPCC conclusions in the various Summaries for Policymakers.

...the incidence of the coffee leafminer (Perileucoptera coffeella) and the nematode Meloidogyne incognita are likely to increase in future in Brazil's production area. The number of coffee leaf miner cycles could increase by 4%, 32% and 61% in 2020, 2050 and 2080, respectively, under the SRES A2 scenarios (Ghini, 2007). (C5; minor)
This statement originates from Section 13.4.2 of Chapter 13 (page 597, right column). We have a minor comment to make on this statement. The reference to the paper by Ghini et al. (2007) was listed as having been submitted to the journal *Climatic Change,* but was never published in *Climatic Change* (C5). It was published in *Pesquisa Agropecuária Brasileira, Brasília* 43 (2): 187-194, in 2008 (Ghini et al., 2008). We are of the opinion that referring to submitted papers that have not been accepted for publication is incorrect, since they have not yet completed the peer-review process. Moreover, the reference may end up to be untraceable, as was the case here. In our opinion, papers should at least be accepted for publication, or be in press, so that traceability is guaranteed. This minor comment has no consequences for the IPCC conclusions in the various Summaries for Policymakers.

A highly stressed condition is projected between 2015 and 2025 in the water availability in Colombia, affecting water supply and ecosystem functioning in the páramos (IDEAM, 2004), and very probably impacting on the availability of water supply for 60% of the population of Peru (Vásquez, 2004). The projected glacier retreat would also affect hydroelectricity generation in some countries, such as Colombia (IDEAM, 2004) and Peru; one of the more affected rivers would be the Mantaro, where an hydroelectric plant generates 40% of Peru's electricity and provides the energy supply for 70% of the country's industries, concentrated in Lima (UNMSM, 2004). (E2; minor)
In this statement, taken from Section 13.4.3 of Chapter 13 (page 598, right column) we found that the references to UNMSM and Vasquez had been mixed up. The statement on the water supply in Peru is not supported by the Vásquez (2004) paper, but by UNMSM (2004). and the statement on hydro-electricity in the Mantaro river is supported by Vásquez (2004) (E2). This minor inaccuracy has no impact on the IPCC conclusions in the various Summaries for Policymakers.

References

Arnell, N.W., 2004. Climate change and global water resources: SRES emissions and socio-economic scenarios. Global Environ. Change, 14, 31-52.

Cox, P.M., R.A. Betts, C.D. Jones, S. Spall and I.J. Totterdell, 2000. Acceleration of global warming due to carbon-cycle feedbacks in a coupled climate model. Nature, 408, 184-187.

Cox, P.M., R.A. Betts, M. Collins, P. Harris, C. Huntingford, C.D. Jones, 2004. Amazon dieback under climate-carbon cycle projections for the 21st century. Theor. Appl. Climatol. 78, 137–156. (doi:10.1007/s00704-004-0049-4)

FAO, 2002. El cambio climático y los bosques. Boletín electrónico Julio 2002, FAO, Rome. http://www.ecosur.net/cambio_climatico_y_los_bosques.html.

Ghini, R., E. Hamada, M.J. Pedro Júnior and J.A. Marengo, 2007. Climate change and coffee pests in Brazil. Climatic Change, submitted.

Ghini, R., E. Hamada, M.J. Pedro Júnior and J.A. Marengo, 2008. Risk analysis of climate change on coffee nematodes and leaf miner in Brazil. Pesquisa Agropecuária Brasileira, Brasília 43 (2): 187-194.

Nepstad, D.C., A. Veríssimo, A. Alencar, C. Nobre, E. Lima, P. Lefebvre, P. Schlesinger, C. Potter, P. Mountinho, E. Mendoza, M. Cochrane, V. Brooks, 1999. Larg e scale impoverishment of Amazonian forests by logging and fire, Nature, Vol. 398, 8 April.

Rowell, A. and P.F. Moore, 2000. Global Review of Forest Fires. WWF/IUCN, Gland, Switzerland, 66 pp. http://data.iucn.org/dbtw-wpd/edocs/2000-047.pdf.

UNMSM, 2004. Calor intenso y largas sequías. Especials, Perú. http://www.unmsm.edu.pe/Destacados/contenido.php?mver=11.

Vásquez, O.C., 2004. El Fenómeno El Niño en Perú y Bolivia: Experiencias en Participación Local. Memoria del Encuentro Binacional Experiencias de prevención de desastres y manejo de emergencias ante el Fenómeno El Niño, Chiclayo, Peru. ITDG, 209 pp.

North America 10

10.1 Analysis of statements in Table SPM.2 of the Synthesis Report

Warming in western mountains is projected to cause decreased snowpack, more winter flooding and reduced summer flows, exacerbating competition for over-allocated water resources.

This statement is fully supported by the underlying material.

In the early decades of the century, moderate climate change is projected to increase aggregate yields of rain-fed agriculture by 5 to 20%, but with important variability among regions. Major challenges are projected for crops that are near the warm end of their suitable range or which depend on highly utilised water resources. (C3; minor)

From Chapter 14 and the references therein we could not derive the reasoning that led to the 5 to 20% range of yield increases under moderate climate change. Of the six references named in the chapter, Adams et al. (2003), appears to be the main reference. Adams et al. report (in their Table I) changes in rain-fed yield, from –8% to +41% for 2060 (with adaptation) (C3). Adams et al. and other references (Thomson et al. 2005, Tsvetsinkaya et al., 2003) show there are regions with significant yield *decreases* for specific rain-fed crops (5 to 25%), even if adaptation measures are adopted. It could be argued that this observation is covered by the phrase 'but with important variability among regions', but this could not be derived from the chapter text. The IPCC authors provided us with the reasoning that had been followed: for Adams et al. (2003), the projected yield changes for the four food crops considered (corn, soy, wheat, sorghum) are +7, +17, +13, and +5% respectively, according to the Regional Climate Model with adaptation. The whole idea of that paper was that the Regional Climate Model gave more credible projections than the Global Climate Model, so those are the numbers that the IPCC authors used. Furthermore, they confirmed that they highlighted variability due to, for example, different varieties of wheat with the statement that there is 'important variability among regions'. They found it hard to see how they could have been more precise without reporting individual values from tables. We believe that the above explanation of the reasoning behind the 5 to 20% range could have been made more transparent with just a few extra lines of text. We wish to add here that the IPCC authors' expert judgment had been based on a consideration of a vast body of literature and we have no reason to doubt the quality and correctness of the expert judgment.

Cities that currently experience heat waves are expected to be further challenged by an increased number, intensity and duration of heat waves during the course of the century, with potential for adverse health impacts).
This statement is fully supported by the underlying material.

Coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution.
This statement is fully supported by the underlying material.

10.2 Additional findings

Figures TS.15 and 14.1 on the economic damages from hurricanes. (minor)
Figures TS.15 (Technical Summary, page 55) and 14.1 (Chapter 14, page 621) in the Working Group II Report illustrate the statement in the Technical Summary that reads *'Over the past several decades, economic damage from hurricanes in North America has increased over fourfold, due largely to an increase in the value of infrastructure at risk'*. We have a minor comment to make on the figures. Because of a shorter averaging period at the end of the time series (6 years instead of 10), the most recent increase was higher, compared with the increase that would have resulted from applying a uniform averaging period at the end of the series. However, a different choice of statistical method would not have affected the statement. Furthermore, we have found this statement to be fully supported by the underlying material. This minor comment has no consequences for the IPCC conclusions in the various Summaries for Policymakers.

References

Adams, R.M., B.A. McCarl and L.O. Mearns, 2003. The effects of spatial scale of climate scenarios on economic assessments: An example from U.S. agriculture. Clim. Change, 60, 131-148.

Brown, T. J., B. L. Hall and A. L.Westerling, 2004. The impact of twenty-first century climate change on wildland fire danger in the western United States:An applications perspective. Clim. Change, 62, 365-388.

Flannigan, M.D., K.A. Logan, B. D.Amiro,W. R. Skinner and B. J. Stocks, 2004. Future area burned in Canada. Clim. Change, 72, 1-16.

Thomson, A.M., R.A. Brown, N.J. Rosenberg, R.C. Izaurralde and V. Benson, 2005. Climate change impacts for the conterminous USA:An integrated assessment. Part 3:Dryland production of grain and forage crops. Clim. Change, 69, 43-65.

Tsvetsinskaya, E.A., L.O. Mearns, T. Mavromatis, W. Gao, L. McDaniel and M.W. Downton, 2003. The effect of spatial scale of climatic change scenarios on simulated maize, winter wheat, and rice production in the southeastern United States. Clim. Change, 60, 37-72.

11 Polar regions (Arctic and Antarctic)

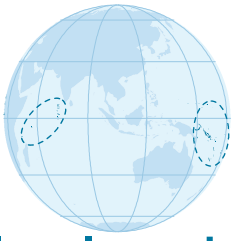
11.1 Analysis of statements in Table SPM.2 of the Synthesis Report

The main projected biophysical effects are reductions in thickness and extent of glaciers, ice sheets and sea ice, and changes in natural ecosystems with detrimental effects on many organisms including migratory birds, mammals and higher predators.
This statement is fully supported by the underlying material.

For human communities in the Arctic, impacts, particularly those resulting from changing snow and ice conditions are projected to be mixed.
This statement is fully supported by the underlying material.

Detrimental impacts would include those on infrastructure and traditional indigenous ways of life.
This statement is fully supported by the underlying material.

In both polar regions, specific ecosystems and habitats are projected to be vulnerable, as climatic barriers to species invasions are lowered.
This statement is fully supported by the underlying material.



12 Small islands

12.1 Analysis of statements in Table SPM.2 of the Synthesis Report

Sea level rise is expected to exacerbate inundation, storm surge, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities.
This statement is fully supported by the underlying material.

Deterioration in coastal conditions, for example through erosion of beaches and coral bleaching, is expected to affect local resources.
This statement is fully supported by the underlying material.

By mid-century, climate change is expected to reduce water resources in many small islands, e.g. in the Caribbean and Pacific, to the point where they become insufficient to meet demand during low-rainfall periods.
This statement is fully supported by the underlying material.

With higher temperatures, increased invasion by non-native species is expected to occur, particularly on mid- and high-latitude islands.
This statement is fully supported by the underlying material.

12.2 Additional findings

Lower rainfall coupled with accelerated sea-level rise compounds the threat on water resources; a 10% reduction in average rainfall by 2050 is likely to correspond to a 20% reduction in the size of the freshwater lens on Tarawa Atoll, Kiribati. (C3; minor)
We have a minor comment to make on this statement. The statement appears in the Technical Summary (Table TS2, page 58; Box TS.6, page 63), in the Executive Summary of Chapter 16 (page 689) and in the main chapter text (pages 696 and 697), and is indicated to have been based on a World Bank report (World Bank, 2000). However, this reference indicates a 14% reduction in the freshwater lens, as a consequence of a 10% reduction in precipitation. Figures change when other factors combine with changes in precipitation; –12% change in the freshwater lens is projected for 0.4 m sea level rise, and –38% for 0.4 m sea level rise in combination with reduced island size due to erosion. The World Bank report also notes that a 10% increase in evapotranspiration would lead to a 6% reduction in the freshwater lens. The chapter text is not clear on why the effect of a projected 10% increase in evapotranspiration should be added to the effect of a projected 10% reduction in

precipitation. The Coordinating Lead Authors explained to us that these changes are correlated and that, hence, the 6% effect from evapotranspiration change should indeed be added to the 14% effect from changes in precipitation. The statement is correct, but we believe that this last point should have been explained in the text. This minor comment has no consequences for the IPCC conclusions in the various Summaries for Policymakers.

Less rainfall coupled with accelerated sea-level rise would compound this threat. Studies conducted on Bonriki Island in Tarawa, Kiribati, showed that a 50 cm rise in sea level accompanied by a reduction in rainfall of 25% would reduce the freshwater lens by 65% (World Bank, 2000). (E2; minor)

Another instance of inaccurate referencing was found in the main text of Chapter 16 (page 697). However, the World Bank study does not report a 50 cm sea level rise. The reference should have been to a study by Falkland (1999) (E2). This minor inaccuracy has no impact on the IPCC conclusions in the various Summaries for Policymakers.

References

World Bank, 2000: Cities, Seas and Storms: Managing Change in Pacific Island. Economies. Vol. IV: Adapting to Climate Change. World Bank, Washington, District of Columbia, 135 pp

Falkland, A., 1999: Impacts of climate change on water resources of Pacific islands. PACCLIM 19 Workshop, Modelling the Effects of Climate Change and Sea Level Rise in Pacific Island 20 Countries. Auckland, New Zealand, 33pp.

Annex A Table SPM.2 of the Synthesis Report: examples of some projected regional impacts

This table including its footnote is a direct copy of the original table SPM.2 on page 11 of *Climate Change 2007 – Synthesis Report, A report of the IPCC.*

Table SPM.2. Examples of some projected regional impacts {3.3.2} **Table A.1**

Africa	• By 2020, between 75 and 250 million of people are projected to be exposed to increased water stress due to climate change. • By 2020, in some countries, yields from rain-fed agriculture could be reduced by up to 50%. Agricultural production, including access to food, in many African countries is projected to be severely compromised. This would further adversely affect food security and exacerbate malnutrition. • Towards the end of the 21st century, projected sea level rise will affect low-lying coastal areas with large populations. The cost of adaptation could amount to at least 5 to 10% of Gross Domestic Product (GDP). • By 2080, an increase of 5 to 8% of arid and semi-arid land in Africa is projected under a range of climate scenarios (TS).
Asia	• By the 2050s, freshwater availability in Central, South, East and South-East Asia, particularly in large river basins, is projected to decrease. • Coastal areas, especially heavily populated megadelta regions in South, East and South-East Asia, will be at greatest risk due to increased flooding from the sea and, in some megadeltas, flooding from the rivers. • Climate change is projected to compound the pressures on natural resources and the environment associated with rapid urbanisation, industrialisation and economic development. • Endemic morbidity and mortality due to diarrhoeal disease primarily associated with floods and droughts are expected to rise in East, South and South-East Asia due to projected changes in the hydrological cycle.
Australia and New Zealand	• By 2020, significant loss of biodiversity is projected to occur in some ecologically rich sites, including the Great Barrier Reef and Queensland Wet Tropics. • By 2030, water security problems are projected to intensify in southern and eastern Australia and, in New Zealand, in Northland and some eastern regions. • By 2030, production from agriculture and forestry is projected to decline over much of southern and eastern Australia, and over parts of eastern New Zealand, due to increased drought and fire. However, in New Zealand, initial benefits are projected in some other regions. • By 2050, ongoing coastal development and population growth in some areas of Australia and New Zealand are projected to exacerbate risks from sea level rise and increases in the severity and frequency of storms and coastal flooding.
Europe	• Climate change is expected to magnify regional differences in Europe's natural resources and assets. Negative impacts will include increased risk of inland flash floods and more frequent coastal flooding and increased erosion (due to storminess and sea level rise). • Mountainous areas will face glacier retreat, reduced snow cover and winter tourism, and extensive species losses (in some areas up to 60% under high emissions scenarios by 2080). • In southern Europe, climate change is projected to worsen conditions (high temperatures and drought) in a region already vulnerable to climate variability, and to reduce water availability, hydropower potential, summer tourism and, in general, crop productivity. • Climate change is also projected to increase the health risks due to heat waves and the frequency of wildfires.
Latin America	• By mid-century, increases in temperature and associated decreases in soil water are projected to lead to gradual replacement of tropical forest by savanna in eastern Amazonia. Semi-arid vegetation will tend to be replaced by arid-land vegetation. • There is a risk of significant biodiversity loss through species extinction in many areas of tropical Latin America. • Productivity of some important crops is projected to decrease and livestock productivity to decline, with adverse consequences for food security. In temperate zones, soybean yields are projected to increase. Overall, the number of people at risk of hunger is projected to increase (TS; medium confidence). • Changes in precipitation patterns and the disappearance of glaciers are projected to significantly affect water availability for human consumption, agriculture and energy generation.

North America	• Warming in western mountains is projected to cause decreased snowpack, more winter flooding and reduced summer flows, exacerbating competition for over-allocated water resources. • In the early decades of the century, moderate climate change is projected to increase aggregate yields of rain-fed agriculture by 5 to 20%, but with important variability among regions. Major challenges are projected for crops that are near the warm end of their suitable range or which depend on highly utilized water resources. • Cities that currently experience heat waves are expected to be further challenged by an increased number, intensity and duration of heat waves during the course of the century, with potential for adverse health impacts. • Coastal communities and habitats will be increasingly stressed by climate change impacts interacting with development and pollution.
Polar Regions	• The main projected biophysical effects are reductions in thickness and extent of glaciers, ice sheets and sea ice, and changes in natural ecosystems with detrimental effects on many organisms including migratory birds, mammals and higher predators. • For human communities in the Arctic, impacts, particularly those resulting from changing snow and ice conditions, are projected to be mixed. • Detrimental impacts would include those on infrastructure and traditional indigenous ways of life. • In both Polar Regions, specific ecosystems and habitats are projected to be vulnerable, as climatic barriers to species invasions are lowered.
Small Islands	• Sea level rise is expected to exacerbate inundation, storm surge, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities. • Deterioration in coastal conditions, for example through erosion of beaches and coral bleaching, is expected to affect local resources. • By mid-century, climate change is expected to reduce water resources in many small islands, e.g. in the Caribbean and Pacific, to the point where they become insufficient to meet demand during low-rainfall periods. • With higher temperatures, increased invasion by non-native species is expected to occur, particularly on mid- and high-latitude islands.

Note:
Unless stated explicitly, all entries are taken from the text of the Working Group II Summary for Policymakers. They are either 'very high confidence' or 'high confidence' statements, related to different sectors (agriculture, ecosystems, water, coasts, health, industry and settlements). The Working Group II Summary for Policymakers refers to the source of the statements, timelines and temperatures. The magnitude and timing of impacts that may ultimately occur will vary according to the amount and rate of climate change, emissions scenarios, development pathways and adaptation.

Annex B The error on the melting of the Himalayan glaciers

In the media, much attention was paid to this erroneous statement in the chapter on Asia, page 493 of Section 10.6.2, which suggested the disappearance of Himalayan glaciers by 2035:

Glaciers in the Himalaya are receding faster than in any other part of the world [...] the likelihood of them disappearing by the year 2035 and perhaps sooner is very high if the Earth keeps warming at the current rate. Its total area will likely shrink from the present 500,000 to 100,000 km² by the year 2035 (E1; major)

Here, we provide an analysis of this error and some background information, which also provides an update that includes literature that became available *after* production and publication of the Fourth Assessment Report.

In the Synthesis Report (IPCC, 2007) and in the Summary for Policymakers (SPM), and the Technical Summary (TS) of the Working Group I contribution to the IPCC Fourth Assessment Report (Solomon et al., 2007), no explicit statements were made on Himalayan glacier retreat. In the Summary for Policymakers of the Working Group II Report (Parry et al., 2007), there was only one reference to the Himalayas:

> *Glacier melt in the Himalayas is projected to increase flooding, and rock avalanches from destabilised slopes, and to affect water resources within the next two to three decades. This will be followed by decreased river flows as the glaciers recede.*

This statement is rather general and correct, although the impact on water resources due to glacier retreat is very likely to be rather limited in the next two to three decades. However, in the Technical Summary, a major error occurred in Box TS6, on page 59:

> *If current warming rates are maintained, Himalayan glaciers could decay at very rapid rates, shrinking from the present 500,000 km2 to 100,000 km² by the 2030s.*

This text was based on page 493 of Section 10.6.2 of Working Group II Report, which states:

Glaciers in the Himalaya are receding faster than in any other part of the world [...] the likelihood of them disappearing by the year 2035 and perhaps sooner is very high if the Earth keeps warming at the current rate. Its total area will likely shrink from the present 500,000 to 100,000 km² by the year 2035 (WWF 2005).

The first mention of '2035' was taken from a publication by the World Wide Fund for Nature (WWF, 2005), which cited a news story (Pearce, 1999) about an unpublished study (Hasnain, 1999) that does *not* estimate a date for disappearance of Himalayan glaciers.

The second mention of '2035', again a major error, was not taken from the (WWF, 2005), but could be traced to a rough estimate (Kotlyakov, 1996) on the shrinkage of *all* non-polar glaciers (excluding those in basins of internal drainage) between the present day and the year 2350. Furthermore, the Himalayan glaciers do not cover 500,000 km², but about 30,000 km², as was correctly indicated in the first sentence of Section 10.6.2, which stated that: *Himalayan glaciers cover about three million hectares*.

In conflict with knowledge of glacier–climate relationships, disappearance by 2035 would require a 25-fold acceleration of the loss rate during the 1999-2035 period, compared to the estimated past loss rate between 1960 and 1999 (Dyurgerov and Meier, 2005), a situation which is extremely unlikely to occur.

Here, we provide some additional background information, mainly based on a study by Oerlemans et al. (2007) and on a recent American Geophysical Union lecture by leading experts in this field (Kargel et al., 2010). The lecture was held on 14 December 2009 in San Francisco, in response to media attention concerning the claim in the IPCC Working Group II Report that the Himalayan glaciers might be gone by 2035 (Parry et al., 2007).

Glacier retreat and water supply

The region-wide average glacier area retreat rate is probably between 0.1 and 0.5% per year. Although the size of the glacier area will change substantially this century, especially in the most vulnerable eastern zone of the Himalayas, glaciers (such as Khumbu and Imja), will *not* disappear entirely, or even mostly, by 2035, as stated in the Working Group II contribution to the Fourth Assessment Report of the IPCC.

All glaciers combined store roughly 3,400 km³ of fresh water. This represents almost three years in combined water discharges from the Indus, the Ganges and the Brahmaputra. The prevalent negative balances of Himalayan glaciers (meaning the annual net withdrawals of ice) total between 0.4 and 1.2% of current river flows, which is not very significant, basin-wide. So, although over half a billion people draw water from these melting glaciers, this only represents between one and a few per cent of their water supplies.

Increased melting may further increase water discharge by 1 to 2%, in the next few decades. Within 50 to 100 years, the discharge could *decrease* by several per cent, as the current negative balance contribution decreases. However, on the scale of the subcontinent, hydrological problems are likely to stem more from population

growth, inefficiency in water resource distribution and application, and from changes in the Monsoon and the Westerlies, due to global warming and changes in the Elevated Heat Pump (EHP). Changes in the Monsoon and the Westerlies already appear to be substantial and are likely to be increasingly impactful.

On a local scale, the seasonal influence of glacier melt can be strong, and even rivers as large as the Indus fluctuate widely throughout the year because of the seasonality of water storage (mostly in the form of ice), and melting of both glaciers and high altitude snow fields. The greatest vulnerability of large numbers of people to glacier state and dynamics is to those in arid and semi-arid lands, such as north-eastern Afghanistan, Uzbekistan, parts of Pakistan, and western China. This concerns tens of millions of people.

Sea level rise

Since 1900, the majority of the observed glaciers around the world are retreating, including those in central Asia. Based on Oerlemans et al. (2007), global glacial contribution to sea level rise was 4.5±0.7 cm during the 1900-2000 period, compared to a total sea level rise of ~19.5 cm in the 1870-2004 period. This estimate is higher than the IPCC estimate of 3.0±1.0 cm for the 20th century, and better explains the observed sea level rise as caused by thermal expansion and changes in the cryosphere. Based on Oerlemans et al. (2007) and Kargel et al. (2010), it is roughly estimated that the annual contribution from Himalayan glaciers to sea level rise is 0.06±0.04 mm, or ~2% of the current annual sea level rise of 3.1±0.7 mm (Parry et al., 2007). The rate of Himalayan glacier melting appears to have increased over time, but so has sea level rise, and therefore the 2% contribution may still apply.

References

Dyurgerov, M.B. and M.F. Meier, 2005. Glaciers and the changing earth system, a 2004 snapshot, Occasional Paper No. 58. Boulder, Institute of Arctic and Alpine Research, University of Colorado: 117

Hasnain, S.I., 1999. Report on Himalayan Glaciology. New Dehli, ICSI working group on Himalayan Glaciology: 22.

IPCC, 2007. Climate Change 2007. Synthesis report. Contribution of Working Groups I, II and III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Core writing team: Pachauri, R.K. and Reisinger, A. (Eds.). Geneva, Switzerland.

Kargel, J.S., R. Armstrong et al., 2010. Satellite-era glacier changes in High Asia. Background support presentation for NASA "Black Carbon and Aerosols" press conference associated with Fall AGU, Dec. 14, 2009. Updated and expanded Feb. 17, 2010.

Kotlyakov, V.M., 1996. Variations of Snow and Ice in the past and at present on a Global and Regional Scale. I. H. PROGRAMME. Paris, UNESCO.

Oerlemans, J., M. Dyurgerov et al., 2007. "Reconstructing the glacier contribution to sea-level rise back to 1850." The Cryosphere 1: 59-65.

Parry, M.L., O.F. Canziani et al., 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability. Cambridge, Cambridge University Press.

Pearce, F., 1999. Flooded Out. New Scientist. 162.

Solomon, S.D., M.M. Qin et al., 2007. Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change., Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

WWF, 2005. An overview of Glaciers, glacier retreat and its subsequent impacts in Nepal, India and China: 67.

Annex C The error on the percentage of Dutch land area below sea level

In February 2010, an error was detected in a text supplied by the Netherlands Environmental Assessment Agency (PBL) for Chapter 12 (on Europe), page 547, Subsection 12.2.3, of the Working Group II contribution to the Fourth Assessment Report, regarding the risks of flooding in the Netherlands:

The Netherlands is an example of a country highly susceptible to both sea-level rise and river flooding because 55% of its territory is below sea level where 60% of its population lives and 65% of its Gross National Product (GNP) is produced. (E1; major)

The error was discovered by a Dutch journalist of a weekly newspaper (Vrij Nederland) who checked information about the Netherlands, triggered by the publicity around the error on the Himalayan glaciers. On page 547 of the chapter text, it says that 55% of the Netherlands is located *below sea level*. This should have read that 55% of the Netherlands is *at risk of flooding* (E1); 26% of the country is at risk because it is located below sea level, and another 29% is susceptible to river flooding.[1)] Examples of the latter are the near floodings in the mid-1990s, of areas along the rivers Meuse and Waal – areas that are well above sea level. The Netherlands is sensitive to climate change. Sea level rise as well as peak river discharges have been analysed frequently, and according to government policy this requires precautionary measures.

The original text that included this error was submitted by the Netherlands Environmental Assessment Agency (PBL) in mid 2005. A similar error also occurred in publications by others. A commentary that was published in Nature in 2005 (Kabat et al., 2005) refers to 60% of the Dutch land area as being located below sea level. In 2007, an English version of a note from the Dutch Ministry of Transport also stated (Dutch Ministery of Transport, 2007) that about 60% of the country was

1) Here, the area of the Netherlands that is prone to flooding has been divided in a binary manner, starting with determining the part of the country that lies below NAP (a particular reference sea level) – which is 26% – the rest of the country at risk of flooding is then categorised as being at risk of flooding by rivers; of course, more finegrained subdivisions could also have been made, since obviously the part of the country that lies below sea level is also at risk of flooding by rivers, and parts of the country that lie above NAP are also at risk of flooding by the sea.

situated below sea level. It would have been correct to state that about 60% of the Netherlands would be prone to flooding by sea if the sea level would rise by 1 m above the 2000 level and a severe storm would hit the coast during spring tide – but this is not the same thing. In the review process of the IPCC Working Group II Report, there were several comments and suggested changes relating to this chapter, but this error remained unnoticed.

Immediately after detection, the PBL reported the error to the international community. It was also reported to the IPCC, and on 27 April 2010 is was included in a list of errata on IPCC reports. The incorrect wording in the IPCC report does not affect the message of the conclusion. The error has no significance for the main conclusions in the chapter, or for those on Europe, nor for the conclusions in the various Summaries for Policymakers.

We acknowledge that this error was not the fault of the IPCC (Coordinating) Lead Authors or Co-Chairs. The error was made by a Contributing Author from the PBL, and the (Coordinating) Lead Authors are not to blame for relying on Dutch information provided by a Dutch agency. The lesson to be learned for an assessment agency such as ours, is that quality control is needed at the primary level of a literature assessment. This should be done by checking basic data, to the extent feasible, even when authoritative references are available. Of course, there are limitations to checking data, given the vast amounts of specific regional information.

References

Kabat, P., Vierssen, W. van, Veraart, J.A., Vellinga, P., Aerts, J., 2005. Climate proofing the Netherlands. Nature, vol. 438, p. 283-284

Ministry of Transport, Public Works and Water Management, 2007. Flood maps in the Netherlands, http://www.safecoast.org/editor/databank/File/folder%20engels%20def%201%20febr07.pdf

Annex D Sea level rise: consequences for the Netherlands

Summary

Errors in the IPCC report regarding the Himalayan glaciers and the Dutch land area below sea level have triggered a discussion on whether the Dutch policies that deal with sea level rise should be revised. The answer is clearly 'no': the contribution from melting Himalayan glaciers to sea level rise is very limited (around 2%). Moreover, the policy concerning safety against flooding in the Netherlands, as formulated in the National Water Policy Plan 2009-2015 (Ministry of Transport, Public Works and Water Management, 2009) and elaborated in the Delta Programme, is well founded on the available knowledge on climate change, sea level rise, river discharges and uncertainties. The current discussions related to the IPCC have no effect on the assumptions under the National Water Policy Plan and the Delta Programme.

There is scientific agreement that the main causes of mean global sea level rise are thermal expansion of sea water and melting of land ice due to increasing temperatures. However, future projections of sea level rise are uncertain because of the large range of temperature projections and the limited knowledge about the melting behaviour of especially the arctic ice shields (PBL2007, Katsman et al., 2008).

Sea level rise: limited contribution from the Himalayan glaciers

Over the last century, the sea levels have risen, world wide, by 14 to 20 cm, corresponding with an average of 1.7±0.3 mm a year (Church et al., 2006). Along the Dutch coast, the sea level rise was of the same order of magnitude: 19 cm with an average of 1.8±0.2 mm a year (PBL, 2010). Satellite data indicate an accelerated trend in global sea level rise of 3.1±0.7 mm a year, over the past 15 years (Church and White, 2006; Rahmstorf et al., 2007). It is unclear whether this acceleration will continue. The effect of glacier melting in the Himalayas on global sea level rise is limited: based on Oerlemans et al. (2007) and Kargel et al. (2010), it is estimated that the annual contribution from the Himalayan glaciers to sea level rise is 0.06±0.04 mm, that is, around 2% of the current annual sea level rise of 3.1±0.7 mm (Parry et al., 2007). Therefore can be concluded that the contribution from the melting of the Himalayan glaciers to sea level rise is very limited.

Estimates on future sea level rise for the Netherlands: large uncertainties

There is scientific agreement that the main causes of mean global sea level rise are thermal expansion of sea water and the melting of land ice due to increasing temperatures. However, future projections of sea level rise are uncertain because of the large range of temperature projections and the limited knowledge about the melting behaviour of especially the arctic ice shields (PBL, 2007; Katsman et al., 2008). The range for temperature rise is due to i) natural variability, such as the recent slowing down of the increase in average global temperature, ii) the climate sensitivity of the atmosphere, iii) uncertainties in atmospheric processes, and iv) uncertainties in future emission of greenhouse gases.

When considering the possible sea level rise for the Netherlands, the most recent estimates on sea level rise for the Netherlands cover a range of 35 to 85 cm for 2100 (KNMI, 2006), or in case of high-end/worst-case estimates, the rise is between 130 cm (Deltacommissie, 2008) and 150 cm (PBL, 2007).

In 2007, in collaboration with the Royal Netherlands Meteorological Institute (KNMI), the PBL explored plausible future extreme sea level rise scenarios for the Netherlands and – based on paleoclimatological data – estimated a worst-case sea level rise of 1.5 m/century (PBL, 2007). Given the technical adaptive capacity of the Netherlands and the considered safety margins, the PBL concluded that, with the available techniques, the delta region of the Netherlands could be kept safe even in case of such an extreme sea level rise, but that in the long term, spatial measures could be required (PBL, 2007). In 2008, the Dutch Delta committee (Deltacommissie) presented a high-end estimate on sea level rise of between 65 and 130 cm for 2100, based on a temperature-rise scenario of 6 degrees, and also concluded that technically the delta region of the Netherlands could protect itself against flooding (Deltacommissie 2008). The maximum ranges for sea level rise given by the IPCC (2007) and the KNMI (2006), were based on scenarios with a maximum of 4 degrees temperature rise. A 6-degree temperature rise thus exceeds the 4-degree scenario of the IPCC, but still lies within the total range of uncertainty with respect to temperature rise (e.g. PBL, 2009, News in Climate Science).

Consequences for policy on safety against flooding

Following the advice of the Delta committee in 2008, the policy on safety against flooding and freshwater management will be revised, given the increases in population and economical values in the area that has been sensitive to flooding since the 1960s, and the challenges imposed by climate change. The recent National Water Policy Plan 2009-2015 (Dutch Ministry of Transport, Public Works and Water Management, 2009) has announced that i) the national standards for the safety against flooding will be reconsidered, and ii) a long-term adaptive strategy on climate proofing of the Netherlands will be constructed, including an analysis of possible consequences for spatial development. To effectuate these points, the Delta Programme has been launched, together with a Delta Act, Delta Fund and a Delta Commissioner responsible for the coordination of the programme. In this Delta Programme, the four available KNMI scenarios (KNMI, 2006) are taken as the plausible range for future uncertainties for the Netherlands, with respect to climate change and sea level rise.

Current investments in the protection against flooding in the Netherlands are justified by the fact that a substantial number of dikes (24%) did not meet present-day safety standards because of insufficient maintenance and new hydrological conditions. The investments that are required for the improvement of the dikes are not fully known yet, because for 32% of the dikes, the quality status is currently unknown (Dutch Ministry of Transport, Public Works and Water Management, 2006).

Given that sea level rise is a slow process and that the uncertainties in future projections are considerable, future additional investments in the safety of the Netherlands will depend on progressing scientific insights. Sea level rise is addressed in the current policy on safety against flooding. For safety measures in coastal areas, decisions with a short lead time (5 years) are based on the present sea level rise of 20 cm/century and – based on earlier KNMI scenarios – decisions with lead times of 50 to 100 years are based on 60 cm sea level rise. Spatial reservations for the long term (100 to 200 years) are based on a high sea level rise of 85 cm. Possible impacts of climate change from floods due to extreme river discharges have also been incorporated in the management strategy 'Room for the River' through spatial reservations in certain areas for which additional measures could be required in the future. Finally, the process of regular evaluations of the quality of the dikes, every six years, will include the advancing knowledge about climate change, sea level rise and its consequences (Dutch Ministry of Transport, Public Works and Water Management, 2009).

An additional, important factor that will determine river discharges in the Netherlands is the river and safety management upstream in the Rhine and Meuse river basins. Since 2009, the EU High Water Directive has been operational. It provides a legal basis for international appointments in flood risk management on the scale of transboundary river basins.

Considering the slow process of sea level rise, the adaptive capacity of the Netherlands with respect to technical measures (e.g., strengthening of dikes, storm barriers, dunes) is thought to be sufficient – even in worst-case scenarios – provided that the required budgets become available (PBL, 2007; Deltacommissie, 2008). However, the study by the PBL (2007) and Ligtvoet et al. (2009) point out that, in the long run, management of peak river discharges will be the main challenge for the Netherlands, and that adaptive capacity concerning spatial developments is limited, because of their relative slowness and irreversibility. Therefore, choices that will be made in the coming decades, in urban development, nature development and configuration of the main water system in the Netherlands, will also determine the future climate resilience of the Netherlands (PBL, 2009). It has been shown that a combination of spatial and technical measures regarding river areas, IJsselmeer area and the south-western delta, may contribute most to reducing the vulnerability of the Netherlands, in both the short term and the long term (Ligtvoet et al., 2009).

Conclusion

The current policy on safety against flooding in the Netherlands, as formulated in the National Water Policy Plan and elaborated in the Delta Programme, is well

founded on the available knowledge on climate change, sea level rise, river discharges and uncertainties. The current discussions about the IPCC have no effect on the assumptions underlying the Dutch National Water Plan.

The required investments in the period up to 2020 (although not fully known yet) are to ensure that the quality of the dikes will meet present-day standards (Water Act). The required future maintenance and investment levels will depend on the new safety standards and the measures that will be adopted within the framework of a long-term adaptive strategy. The recently launched Delta Programme within the framework of the National Water Policy Plan 2009-2015 (Dutch Ministry of Transport, Public Works and Water Management, 2009) contains an extensive research agenda to focus future research on safety against flooding and on freshwater supply in the Netherlands. In addition, the agenda lists the drafting of a long-term adaptive strategy, addressing the still large uncertainties concerning climate change. For 2015, further policy decisions are expected on extra measures and investments for safety against flooding and for freshwater supply. On a political level, it has been decided that within the context of the Delta Programme, by 2020, financial reservations will be made for additional investments and maintenance.

References

Church, J.A., and N.J. White, 2006. A 20th century acceleration in global sea-level rise, Geophys. Res. Lett., 33, L01602, doi:10.1029/2005GL024826. Update data to 2007 on PSMSL website (link to data)

Deltacommissie, 2008. Samen werken aan water. Bevindingen van de Deltacommissie. Deltacommissie, Den Haag, the Netherlands.

Kargel, J.S., R. Armstrong et al., 2010. Satellite-era glacier changes in High Asia.Background support presentation for NASA "Black Carbon and Aerosols" press conference associated with Fall AGU, Dec. 14, 2009. Updated and expanded Feb. 17, 2010.

Katsman, C.A., W.Hazeleger, S.S. Drijfhout, G.J. van Oldenborgh & G. Burgers, 2008. Climate scenarios of sea level rise for the northeast Atlantic Ocean: a study including the effects of ocean dynamics and gravity changes induced by ice melt, Climatic Change 91:351–374

KNMI, 2006. Climate change scenarios for the Netherlands. Scientific report WR 2006-01. Koninklijk Nederlands Meteorologisch Institute, Bilthoven, the Netherlands.

Ligtvoet, W.J. Knoop, B. Strengers & A. Bouwman, 2009. Flood protection in the Netherlands: framing long term challenges and options for a climate resilient delta. PBL publication number 500078004. Netherlands Environmental Assessment Agency – PBL, Bilthoven/Den Haag, the Netherlands.

Ministry of Transport, Public Works, and Water management, 2006. Primaire Waterkeringen getoetst, Landelijke rapportage Toetsing 2006. Ministry of Public Works, Transport and Watermanagement, Den Haag, the Netherlands

Ministry of Transport, Public Works, and Water management, 2009. Nationaal Waterplan 2009-2015. Ministry of Public Works, Transport and Water management, Den Haag, the Netherlands.

Oerlemans, J., M. Dyurgerov et al., 2007. "Reconstructing the glacier contribution to sea-level rise back to 1850." The Cryosphere 1: 59-65.

Parry, M. L., O.F. Canziani et al., 2007. Climate Change 2007: Impacts, Adaptation and Vulnerability. Cambridge, Cambridge University Press.

PBL, 2007. The Netherlands in the future. Second Sustainability Outlook - part Physical Environment of the Netherlands. Netherlands Environmental Assessment Agency – PBL, Bilthoven/Den Haag, The Netherlands

PBL, 2009. Roadmap to a climate-proof Netherlands. PBL publication number 500078003. Netherlands Environmental Assessment Agency – PBL, Bilthoven/Den Haag, The Netherlands

PBL, 2009. News in Climate Science. Netherlands Environmental Assessment Agency – PBL, Bilthoven/Den Haag, The Netherlands.

PBL, 2010. Zeespiegelstand langs de Nederlandse kust en mondiaal, 1891-2008. Versie 7. Compendium voor de Leefomgeving. http://www.compendiumvoordeleefomgeving.nl/indicatoren/nl022907-Zeespiegelstand-Nederland.html?i=9-54. Netherlands Environmental Assessment Agency – PBL, Bilthoven/Den Haag. Statistics Netherlands, Den Haag/Heerlen, Wageningen UR, Wageningen, The Netherlands .

Rahmstorf, S., 2007. A semi-empirical approach to projecting future sea-level rise. Science315: 367-370

Annex E Abbreviations

ASTER
Advanced Spaceborne Thermal Emission and Reflection Radiometer (a remote sensing instrument)

CLA
Coordinating Lead Author

CO_2
Carbon dioxide

CRU
Climate Research Unit (at the University of East Anglia, United Kingdom)

EHP
Elevated Heat Pump

FAO
Food and Agriculture Organization

FOD
First Order Draft

GCM
Global Circulation Model (a type of climate model)

GDP
Gross Domestic Product

GNP
Gross National Product

H-K
Himalaya-Karakoram

IPCC
Intergovernmental Panel on Climate Change

IUCN
International Union for Conservation of Nature

KNAW
Royal Netherlands Academy of Arts and Sciences

KNMI
Royal Netherlands Meteorological Institute

NAP
Amsterdam Ordnance Datum

NCAR
National Center for Atmospheric Research (Boulder, USA)

NGO
Non Governmental Organisation

SOD
Second Order Draft

SPM
Summary for Policymakers

SRES
IPCC Special Report on Emission Scenarios

SYR
IPCC Synthesis Report (of Working Groups I, II and III reports)

TAR
Third Assessment Report of the IPCC

TS
Technical Summary

UN
United Nations

UNFCCC
United Nations Framework Convention on Climate Change

UNMSM
Universidad Nacional Mayor de San Marcos (Lima, Peru)

URL
Uniform Resource Locator (e.g. an internet address)

WG
Working Group

WG I
IPCC Working Group I (on the Science of Climate Change)

WG II
IPCC Working Group II (on Impacts, Adaptation and Vulnerability)

WG III
IPCC Working Group III (on Mitigation of Climate Change)

WWF
World Wide Fund for Nature

Colophon

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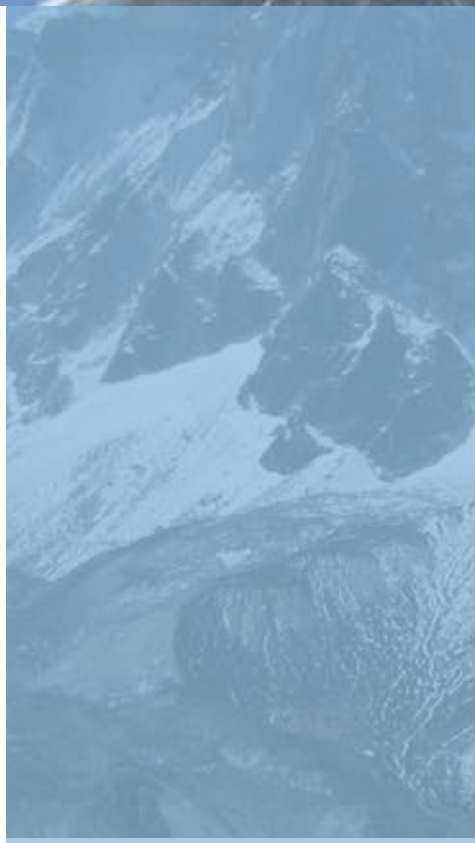

Assessing an IPCC assessment

The Netherlands Environmental Assessment Agency (PBL) has investigated the scientific foundations for the IPCC summary conclusions of the Fourth Assessment Report of 2007 on projected regional climate-change impacts, at the request of the Dutch Minister for the Environment. Overall the summary conclusions are considered well founded and none were found to contain any significant errors.

The Working Group II contribution to the Fourth Assessment Report shows ample observational evidence of regional climate-change impacts, which have been projected to pose substantial risks to most parts of the world, under increasing temperatures. However, in some instances the foundations for the summary statements should have been made more transparent. While acknowledging the essential role of expert judgment in scientific assessments, the PBL recommends to improve the transparency of these judgments in future IPCC reports.

In addition, the investigated summary conclusions tend to single out the most important negative impacts of climate change. Although this approach was agreed to by the IPCC governments for the Fourth Assessment Report, the PBL recommends that the full spectrum of regional impacts is summarised for the Fifth Assessment Report, including the uncertainties. The PBL believes that the IPCC should invest more in quality control in order to prevent mistakes and shortcomings, to the extent possible.