

ipcc

INTERGOVERNMENTAL PANEL ON climate change

**AR5 Scoping Meeting
Venice, Italy, 13-17 July 2009**

AR5-SCOP/Doc. 2
(30.VI.2009)
ENGLISH ONLY

CHAIRMAN'S VISION PAPER

(Submitted by the IPCC Chairman)

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Scoping Meeting for the IPCC Fifth Assessment Report (AR5) Venice, Italy 13-17 July 2009

Instructions on Conduct and Structure of the Scoping Meeting

The scoping meeting is necessarily an intensive exercise with great significance in determining the output of the IPCC in the form of the Fifth Assessment Report (AR5) due to be completed in 2014. As the agenda for the meeting indicates, the work of scoping will be carried out in Plenary Sessions and Breakout Groups (BOGs). In addition, special task groups (STGs) would be set up to deal with cross cutting themes (CCTs) that have been identified in this note. It is entirely possible that additional CCTs may be identified in the course of the meeting, while some of those currently listed may be modified or dropped. Details on how these sessions would be organized are provided in this note.

Breakout Groups

- Breakout groups will deal with each of the three Working Groups and the Synthesis Report. The group for the Synthesis Report would be necessarily small, and would spend enough time listening to discussions in the three Working Groups and interact with participants in the three Working Groups to ensure proper consideration of the evolving structure of each Working Group Report. It is suggested that each Working Group have a designated set of participants which remains stable at a number of thirty three (33) persons each. As in the past there would be a large number of persons who would float between Working Group meetings, and we have found that this is always helpful not only in bringing fresh perspectives but also ensuring linkages across Working Groups.
- As far as the Synthesis Report is concerned it is planned that there would be a regular breakout group of core members numbering about 15. Others would float in and out of this breakout groups, and these 15 would also move in and out of the breakout groups for the Working Groups as required.
- Each Breakout Group should have individuals chairing them throughout the entire meeting. As far as the Working Groups are concerned it would be the Co-Chairs of respective Working Groups who would chair the breakout sessions, and in the case of the Synthesis Report the Chairman would start by chairing the first session of the breakout group, and would then appoint two persons as Co-chairs to carry the process through.

Special Task Groups (STGs) for Cross Cutting Themes

- Cross cutting themes are those that extend across and involve multiple Working Groups. On this basis the following categorized list is provided.
 - *Category A (Involving all Working Groups)*
 - Hydrological cycle
 - The global carbon cycle
 - Regional aspects and details
 - Risk and uncertainty
 - Geoengineering
 - Alternative GHG metrics & new greenhouse gases

○ Category B (Involving two Working Groups)

- Mitigation, adaptation, and sustainable development
- Costing and economic assessment

Involving
Working Groups
II & III

- Ice sheets and sea level rise
- Ocean acidification
- Extreme events

Involving
Working Groups
I & II

Structure of the STGs

- Depending on the subject area, each STG would be composed of a core of 4 to 8 persons, plus 2 to 4 each from relevant Working Groups. In addition, we would have persons floating in and out of these groups and contributing to discussions within an STG and across STGs.
- A detailed schedule for meetings of Breakout groups and STGs will be provided at the meeting.

Chairman's Vision Paper (with inputs from IPCC Vice-Chairs and Co-Chairs of Working Groups and the Secretary of the IPCC)

A. Chairman's Vision

Background

The IPCC has had unparalleled success as an intergovernmental body mobilizing the best available expertise from all over the world and assessing available scientific knowledge to address an issue of global importance to human society and all living beings on this planet. The IPCC's four comprehensive assessments and numerous special reports have assembled and evaluated the scientific knowledge on the science of climate change, on impacts and vulnerability, and on options for adaptation and mitigation. Based on an approach that is open, thorough, and scientifically rigorous, the contributions of the IPCC are widely recognized as the authoritative source of scientific information on climate change and as key foundations for negotiations and decisions related to implementing the UNFCCC.

The IPCC Fourth Assessment Report (AR4), released in 2007, assessed a large number of important advances in climate change science. It concluded not only that warming in the 20th century is unequivocal, but also that most of the warming in the second half of the 20th century was very likely due to the observed increase in atmospheric greenhouse gases released through human actions. It documented diverse trends in climate and climate impacts, ranging from sea level rise and retreat of mountain glaciers to increases in wildfires and risks of heat waves. The AR4 characterized a wide array of possible future scenarios, documenting the consequences for and the uncertainties in agriculture, human health, biodiversity, infrastructure, and a host of other sectors, assembling the scientific knowledge on regions and specific stakeholder groups, as well as for the entire globe. In addition, the AR4 assessed options for mitigating and adapting to climate change, concluding that a wide range of approaches can be effective and affordable, contributing to broad-based development goals at the same time they help with climate change.

The AR4 and the earlier IPCC assessment reports made critically important contributions, but much remains to be done. The AR4 identified a number of areas where additional knowledge is needed. Among these areas are extremes, including hurricanes; sea-level rise; impacts of interacting stresses; limits to adaptation; and the economics of a range of mitigation options at different points in the future. In addition to being authoritative assessments, the IPCC reports are powerful motivators for research. New research on many of the understanding gaps identified in the AR4 is underway and advancing, with both the scientific community and the world's governments strongly supportive of a successful next IPCC assessment, the Fifth Assessment Report (AR5).

The AR5 is being undertaken at a time when governments, the public and other stakeholders are increasingly concerned and widely informed about climate change. It is also occurring at a time when the political and scientific landscape is increasingly multi-dimensional and complicated. Negotiations related to the UNFCCC are prominent, as are policy discussions in many other fora. Scientific information on climate change continues to accumulate at a rapid pace. In addition, various organizations including several NGOs and UN organizations have started to undertake various forms of assessments, but these of course do not pursue the IPCC's open peer reviews and other procedures or practices involved in approval by governments.

Several topics are emerging as central to future assessments. One is the economics of climate change: Governments, the business community and other stakeholders in the civil society are concerned about the costs of unabated climate change as well as about the costs of emissions reduction. The scientific debate on the economics of climate change is now including issues that have been neglected in the past like decision making under uncertainty, inter- and intra-generational justice, the costs of mitigation when the availability of technologies is limited or participation in international agreements is delayed, and the economics of adaptation. Therefore, the economics of climate change has become a new challenge for the AR5.

Other key challenges include the humanitarian aspects of climate change, wherein the relationship between climate change and its effects on human society in various parts of the world present a crucially important subject for assessment, and ethical dimensions of climate change, which emanate from the disparities between responsibility for climate change and the diverse nature and magnitude of impacts. For these and other issues, new scientific knowledge will be critical for advancing the assessment beyond the level that was possible in previous IPCC reports.

The key issues to be addressed in the AR5 will be identified based on both new information and changing perspectives or new areas of global interest. Some of the most important topics emerge from new ways of thinking about old problems. Key issues that arise in the light of the recent progression of thinking include the following:

- In assessing the impacts of climate change, and particularly in dealing with the socio-political and economic aspects involved, it is essential to separately assess humanitarian and economic impacts. This is crucial because many values relevant for the livelihood and wellbeing of humans and the environment they live in cannot be quantified in monetary terms. The costs of adaptation are equally important, with some components that can be expressed in monetary terms and some that cannot.
- Global thinking is increasingly concerned about the issue of sustainable development and progress toward the Millennium Development Goals (MDGs). Considerable new literature is now available on to the relationship between the MDGs and climate change, but the topic has many dimensions and many challenges. A careful assessment can provide important guidance on progress as well as areas where more work is needed.
- Much recent thinking concerns paths available to human society for a possible transition to a state that can be considered acceptable in terms of the impacts of climate change. This concept is increasingly important not only in policy discussions but also in the design of future scenarios to be assessed by the IPCC.
- Substantial new information and knowledge are available from the implementation of other multilateral agreements. There is considerable interest in exploring implications of these for climate change.
- The negotiations towards an agreement at COP 15 in Copenhagen this December are stimulating a great deal of interest in research on institutional mechanisms and processes by which actions are taken to meet the challenge of climate change. The AR5 will have the opportunity to address this subject in much greater detail than in previous assessments.

New Information and Knowledge

As mentioned earlier the IPCC AR5 is being taken in hand at a time when awareness on climate change issues has reached a level unanticipated in the past. Much of this change can be attributed to the findings of the AR4 which have been disseminated actively through a conscious effort by the IPCC, its partners and most importantly the media. Expectations are, therefore, at an all time high as far as the AR5 is concerned.

The science of climate change is advancing rapidly, and the authoritative assessments of the IPCC appear at intervals of several years. In recent months, some publications in the scientific literature and the media have suggested that the IPCC AR4 and its projections are already outdated or are rapidly becoming so. This perspective mischaracterizes the role of the IPCC assessments, which are designed to encourage and provide a foundation and context for new information, as well as a mechanism for integrating new information into the larger framework of existing knowledge. Still, participants of the Scoping Meeting will need to consider the pace at which new information is appearing and the procedures to ensure that the AR5 covers the complete range of possible futures. This includes exploration of the specific issues listed below:

- Carbon cycle, feedbacks, and interactions with other cycles
- Ocean ecosystems and in particular ocean acidification in all its dimensions
- Clouds, aerosols, black carbon and atmospheric chemistry

- Sea level rise and its regional expression, dynamics of large ice sheet and potential instabilities
- Evolution and trends related to a range of new technologies
- Costs of different stabilization levels and corresponding costs of adaptation
- Infrastructure investments when adaptation and mitigation policies are taken into account
- Evolution and trends in GHG emissions
- Specific regional information on various aspects of climate change, including knowledge in literature in languages other than English

The expert participants in the scoping meeting will be quite capable of identifying new trends in the scientific literature and information available in a number of other fields as well. Another issue on which expectations are very high concerns instabilities and irreversibilities of climate change, often called "tipping points", and questions on when we might reach these, based on realistic projections. These represent another dimension of the concept of dangerous anthropogenic interference with the climate system, the subject of Article 2 of the UN Framework Convention on Climate Change (UNFCCC). As previous assessments have, however, clearly established, because the notion "dangerous" involves value judgements, the scientific assessments of the IPCC address some but not all components of defining dangerous anthropogenic interference with the climate system. An important issue, therefore, is whether the AR5 can provide enough knowledge and information by which the work of the negotiators can be facilitated in defining what would be "dangerous".

Responding to suggestions from policymakers and ensuring the policy relevance of AR5

The AR5 benefits from the huge volume of extremely valuable suggestions and comments that governments have provided for its development. It is certainly not possible to summarize all the valuable suggestions that were received, but some key issues drawn from these comments have been listed for consideration in the scoping meeting¹. These issues only represent subjects of emphasis that emerged from the extensive submissions provided by governments in relation to the AR5. Hence, these are not grouped according to specific Working Groups or the Synthesis Report, but issues that would be considered in the relevant portions of each of these reports.

- A comprehensive and complete assessment of all activities contributing to climate change with detailed lifecycle analysis and broader environmental consequences of the impacts of climate change as well as mitigation options. In the case of mitigation it would be essential to detail in considerable depth the co-benefits that would be produced as a result. In the economic assessment of mitigation options related co-benefits need to be taken into account fully. It would also be essential to explore and assess alternative institutional structures and policy instruments by which mitigation actions can be implemented.
- Climate change needs to be assessed in the context of sustainable development, and this consideration should pervade the entire report across the three Working Groups. In past assessments sustainable development and its various linkages with climate change were seen largely as an add-on. Most governments who have commented on this issue have highlighted the need to treat sustainable development as an overarching framework in the context of both adaptation and mitigation.
- The human consequences of climate change and response strategies, including gender, legal, equity aspects e.g. food security and poverty concerns, legal and humanitarian consequences of climate change induced migration (due to extreme events as a result of unmitigated climate change). These need to be integrated in sector chapters of WG 2 and 3, but treated as a separate topic in the SYR (to avoid being considered as add-on while on the other hand giving those issues high profile).

¹ A more comprehensive summary of recent submissions from governments and organizations has been prepared by the IPCC Secretariat and is contained in document AR5-SCOP/Doc.3. A compilation of submissions is contained in document AR5-SCOP/INF.1. Submissions received in the year 2008 and synthesis and discussions papers based on them are listed under background documentation for the meeting and can be accessed from the IPCC website.

- Issues of historical responsibility, relative burden sharing, equity, compensation and insurance should be addressed on an integrated basis when considering impacts, adaptation, and mitigation.
- Mitigation strategies need to be carefully separated in accordance with timeframe for implementation, and both technical as well as socioeconomic aspects would need to be covered. Given the variations across regions and sub-regions, relevant mitigation strategies would, therefore, need to be framed within a matrix of different time spans, namely short, medium and long-term as well as locations.
- A clear delineation of natural variability in climate and anthropogenic impacts has to be carried out and explored within global as well as regional impacts of climate change. Hence, statements and findings related to attribution would need to be made with precision.
- Adaptation strategies, like mitigation options, need to be assessed within a dynamic framework taking into account both short- and long-term perspectives. These would be related to specific levels and types of impacts, with assessment of socioeconomic costs and benefits that are derived from proactive vs. reactive measures.
- The treatment of uncertainty across the AR5 needs to be characterized by a consistent approach. Statements defining uncertainty would, therefore, require careful design as well as an identification of causes of uncertainty. Similarly the perception and description of risk would need to be related to the needs of policymakers.

Statements by governments have also highlighted several issues that relate to the approach and methodology to be used for different parts of AR5 as well as subjects that require adequate emphasis. Again the list of items provided below are not exclusive of topics to be dealt with in one Working Group Report or the other or in the Synthesis Report, but issues that would need to be kept in focus in specific parts of the AR5. As a practical approach it would be useful for participants in the scoping meeting to go through this extensive list and see where each item would have specific relevance in a specific part of the report.

Radiative forcing

- Gases/forcings not covered by the Kyoto Protocol
- Alternative metrics
- Air pollution, ozone precursors, sulphate aerosols, black carbon and other precursors of climate change
- Chemical and biological feedbacks
- Stratospheric processes, recovery of the ozone hole
- Full impacts of aviation
- Interchangability of baskets of emissions within a climate change context

Regional modelling, clouds aerosols, uncertainties etc.

- Long term modelling
- Regional modelling
- Ice related issues in the context of land and sea.
- Irreversible and abrupt changes and feedbacks related to them.

Food, managed forests, biomass

- Disaggregation of agricultural production modes by region, size of land holdings and technology used
- Specific consideration of current and projected sources/sinks and their potential, implications of climate change impacts
- Human dimensions, including employment, gender, dependence on ecosystem services
- Food-biofuel competition based on technology and type of biofuel
- Long term changes in carbon stocks

Biodiversity, ecosphere (feedbacks)

- Observations and projections
- Paleo data analysis
- Species at risk of extinction or migration
- Resilience of specific ecosystems

Oceans

- Carbon-uptake
- Acidification, biosphere, coastal protection
- Other biotic stresses for different levels of climate change
- Changes in circulation

Water, hydrology

- Changing needs of human populations, demographic changes, agriculture, industry and commerce
- Changes in availability & flow due to climate change
- Hydropower and implications of climate change.

Settlements, infrastructure

- Cities, rural settlements and implications of mix
- Present level and projections of infrastructure, transport and mobility
- Integration of adaptation and mitigation in planning
- Coastal zones and vulnerability of ports and coastal infrastructure

Vulnerable regions, sectors, systems and hot spots

- Small islands developing states
- Least-developed countries
- Drylands, deserts, and desert like regions
- Mountain ecosystems
- Mediterranean region
- Boreal, Arctic, Antarctic, Greenland

Human security

- Food, water, shelter, health, and impacts of climate change
- Migration and immigration – legal, equity, and security issues
- Employment and impacts of climate change as well as opportunities in different regions
- Gender aspects, children, elderly, and climate change impacts, adaptation & mitigation
- Potential conflicts and climate change
- Regional disaggregation & differences
- Equity issues related to historical responsibility, differential impacts, and vulnerability
- MDGs, energy access, poverty, and climate change

Feedbacks related to C/N/P cycles

- Chemical and biological changes
- Carbon-fertilization
- Methane
- Oceans
- Forests and soils

Scenarios, storylines, second best scenarios

- Investigation of the links between storylines (population, society, development, economy, etc.) and costs (mitigation and adaptation with the associated non-climate effects, and damages)
- Upper limits for different temperature changes
- Feasibility of low levels of emissions and concentrations

- Inevitable climate change and inertia
- Implications of peaking time of GHG emissions
- Disaggregation of emissions pathways according to regions
- Interchangability of baskets of emissions
- Discount rates and their effect on viability of adaptation and mitigation measures
- Accelerated technological change
- Lifestyle changes, including dietary changes, habitat and consumption patterns

Mitigation

- Assessment according to needs, not just sectors (food, transport etc.), disaggregated for regions
- Detailed technology assessment
- Transition paths of low carbon society
- Geo-engineering, nuclear (fusion, fission) options
- R&D, technology transfer and institutional structures
- Distribution patterns of low carbon technology (past, current, future)
- Life cycle analysis of all options
- Assumptions for fossil fuel availability and production in the future
- Assessment of past and current practice, culture and development pathways
- Lifestyles, social acceptability of different options and public awareness
- Integration with adaptation and linkage with sustainable development

Adaptation

- Assessment of current and past practice
- Autonomous adaptation and implications
- Limits of adaptive capacity and systemic capability
- Adaptation to unavoidable climate change under different conditions
- Extreme events and disasters
- Link with mitigation and sustainable development

Economics and costs

- Non monetary and humanitarian impacts
- Definition of economic concepts and their applicability under different conditions
- Discount rates and implications for adaptation & mitigation
- Cost of inaction in humanitarian and monetized terms
- Cost-benefit analysis of adaptation and mitigation measures (including co-benefits, equity issues and implications for sustainable development)
- Cost-effectiveness of measures, evaluation of past practice and trends
- Use of market instruments for mitigation and adaptation
- Insurance and compensation

Education, communication, social science

- Analysis of barriers to disseminating knowledge
- Acceptability of change and attitudinal barriers and inertia
- Risk perception and psychology of risk

Synergies and tradeoffs with other Multilateral Environmental Agreement (MEAs)

- Biodiversity
- Desertification
- Forests
- Air pollution
- Ozone depletion

Other issues:

- Regions
 - More information disaggregated according to regions/sub regions
 - In general regional definition to remain as in AR4 for ease of time based comparison but disaggregate within regions
- Climate extremes (raised in numerous submissions)
- Consistency in time scales used across working groups

As far as the three Working Group Reports are concerned the Co-Chairs and TSUs have drafted detailed inputs that follow in serial order.

It may be clarified that at this stage no attempt has been made to consider a structure for the Synthesis Report, because this would have to evolve iteratively by initially considering the needs of policymakers in detail as brought out essentially in the submissions provided by governments and then pursuing the evolution of the structure in each Working Group. This would essentially require that the Synthesis Report while derived from the contents of the three Working Group Reports as laid down in IPCC procedures is a true synthesis of the material produced within an integrated design rather than a “cut and paste” compilation.

B. Contributions of the three Working Groups

Contribution of Working Group I (May 8, 2009)

Introduction

The WGI contribution to the IPCC AR4 concluded that warming in the climate system is unequivocal, documenting and assessing a large number of observed changes in different components. Significant progress was marked by the attribution statement that concluded it is *very likely* that most of the observed increase in global average temperatures since the mid-20th century is due to the observed increase in anthropogenic greenhouse gas concentrations. Projections were based on a multi-institution, multi-model approach that produced an unprecedented amount of model results available for analysis by the scientific community.

The purpose of this short paper is to present a range of emerging topics which need to be addressed in WGI's contribution to the IPCC AR5. It will serve as the basis of the discussion before, and during, the forthcoming Scoping Meeting in Venice in July 2009. The focus is on issues where new science has been able to significantly improve our understanding of key uncertainties. Special attention will be focused on regional climate change as derived from global models as well as observations, modes of variability and projections.

The guiding principles underlying the WGI contribution to the AR5 are to assess with scientific rigor the physical science basis of climate change as it is firmly rooted in the published literature and to bring forward the robust results in such a way that is accessible and useful to the stakeholders. This includes strong links with the other Working Groups, which shall be established early through a range of instruments such as Expert Meetings and IPCC Workshops. The WGI assessment will address the full range of time scales (from decades to millennia) and space scales (from global to regional). This requires the consideration of the couplings between physical and biogeochemical processes and their influence on the sensitivity of the climate system, as well as the assessment of irreversible changes on the range of spatial scales in various components of the climate system.

Emerging Topics:

Detection and attribution of regional climate change is the natural extension of the physical science basis that so far was limited to large-scale quantities such as global mean temperature change. Extension is made possible by a naturally increasing signal-to-noise ratio in observations

associated with progressing climate change, as well as better resolved global climate models, and improved process understanding. Post-AR4 research has reported successful detection and attribution of changes in polar ice coverage, zonal mean precipitation, and others. One focus in the assessment performed by WGI would be the detection and attribution of changes on regional scales, as well as changes in climate modes (e.g., El Niño - Southern Oscillation (ENSO) or North Atlantic Oscillation (NAO)) and extreme events. This assessment will be performed in a coherent way with WGII, which will be facilitated by a joint WGI-WGII Expert Meeting on this topic to be held in September 2009.

Climate projections have been a cornerstone of all previous IPCC Assessment Reports and this will continue to be the case in the AR5. Recent advances in climate modelling could provide the basis to focus on both (i) short-term climate predictions (to 2030) using the most complex coupled climate models available, and (ii), long-term climate projections extending beyond 2100 using climate models of different complexities. Efforts targeted in these directions are already underway or planned within the climate modelling community (e.g. CMIP5 of WCRP). The output from these models in long-term experiments will inform the assessments by WGII and WGIII on adaptation and mitigation, and this has been taken into account in developing the overall timetable of the AR5.

Climate projections require the definition and use of emissions scenarios. The overall climate response to these scenarios differs little over the next decade or two. This may provide opportunities to assess **short-term climate predictions**, based on high-resolution global models that include consideration of some of the possible natural changes as well as human-induced changes, some of which may already be unavoidable. It is anticipated that this will provide information that is required by WGII in its assessment of adaptation to climate change. In this context, the **multi-model approach** applied for the AR4 will be further developed. Science and methods from related fields such as weather prediction may be available that indicate various novel ways in which more information can be drawn from the rapidly growing database of climate model simulations. An IPCC Expert Meeting on multi-model evaluation is organised by WGI with support from WGII and will be held early in 2010.

Long-term climate projections, extending beyond 2100, need to be highlighted further, as the definition of dangerous climate change cannot solely be based on short-term changes but also needs to consider the slower timescales inherent in the climate system, as expressed in lagged sea-level rise, for example. The AR4 started to assess longer time-scales and climate change commitments from earlier emissions, but interest in this topic has been increasing since then, and a range of models of different complexities has been applied to study these questions. Topics that will require further attention are (i) the quantification of allowable emissions for stabilisation of atmospheric greenhouse gases and/or climate, including considerations of geo-engineering and other mitigation options, (ii) the quantification of long-term climate and ecosystem commitments as well as (iii) the concerns about potentially irreversible climate change on human timescales.

Sea level rise is caused by a number of processes with contributions from: (i) thermal expansion of the ocean, (ii) melting of glaciers and small ice caps, (iii) melting of Greenland and Antarctica, (iv) changes in circulation, and (v) changes in land storage. Both the size and the uncertainty of each of these contributions need to be quantified for a useful projection of sea level rise and its regional expression. Major uncertainties associated with the response of the two large ice sheets, Antarctica and Greenland, to the direct effects of warming and changes in accumulation (snow fall) as well as to the indirect effects (ocean warming, sea level rise feedback) have so far remained the primary source of uncertainty for comprehensive sea level projections. This is compounded by the possibility of ice stream and whole **ice sheet instabilities** that may be triggered by slow changes. In particular, renewed discussion of instabilities of the West Antarctic Ice Sheet and of thresholds for a Greenland ice sheet meltdown requires extensive assessment. The lack of both scientific understanding and a sufficient observational base concerns primarily ice sheet-bedrock interactions as well as ice sheet hydraulics. WGI will propose to the next IPCC Plenary in October 2009 the possibility of holding an IPCC Workshop or Expert Meeting on this topic in mid-2010 in order to organise the information in this complex area more coherently.

Carbon cycle – climate feedbacks have already been identified in the IPCC AR4 as significant. At that time, only a few comprehensive climate models had explicitly taken an interactive carbon cycle into account. For the AR5, it is expected that a larger number of such comprehensive models will be available. However, the uncertainties associated with, for example, the response of soils and vegetation to increased warming and changes in the hydrological cycle, or changes in the physical and biogeochemical status of the ocean due to **ocean acidification** and climate change increase the uncertainties of climate projections for the next century. In addition, recent studies have highlighted the importance of combining carbon and other elemental cycles (such as nitrogen, iron, sulphur) interactively in order to capture the full dynamics of global biogeochemical cycles and their feedbacks on climate. In particular, joint assessment of the **carbon and nitrogen cycles** is expected to improve the mechanistic understanding of feedback processes and their strength.

Modes of climate variability to a large extent determine regional climate and extreme events in many regions of the world. Changes in modes, such as ENSO, NAO, Indian Ocean Dipole (IOD), Madden Julian Oscillation (MJO), Inter-decadal Pacific Oscillation (IPO), and decadal variability, are important in assessing and projecting regional climate change and its impacts. Attention can be directed to the past changes of these modes as new and better-resolved information becomes available from paleoclimatic studies and observations. This includes a critical evaluation of climate models regarding their performance in representing time and space characteristics of the major modes of climate variability.

Regional climate change can now be addressed on the basis of high-resolution global climate models that provide a globally consistent basis for projections. The possibility of using enhanced graphical interfaces that may be developed in the course of the AR5 to provide more value for the users will be discussed. A particular focus in assessing regional climate change will be changes in the hydrological cycle, which could be addressed as a cross-cutting issue. One specific, related question is how the behaviour of monsoon circulations may change in future. A further important issue is the possibility of improving projections of possible changes in the frequency and intensity of climate extremes. This topic will be among those assessed by WGI in its contribution to the IPCC Special Report on Extreme Events and Disasters.

Irreversibility of climate change has generated renewed interest as models indicate the very long residence time of climate changes in the Earth system. This is associated with the slow-responding components such as the ocean, the terrestrial ice sheets, and the fact that a fraction of the emitted atmospheric CO₂ has an infinite lifetime in the atmosphere. Abrupt, irreversible climate change has been linked to the melting of permafrost, to changes in vegetation, and to changes in oceanic and atmospheric circulation. Most of the information regarding irreversible and abrupt climate change comes from recent paleoclimatic studies of marine, terrestrial and cryospheric proxy data. This can now be assessed in combination with model simulations and projections.

The IPCC AR4 derived the combined radiative forcing of all anthropogenic forcing agents, the **drivers of climate change**, including CO₂, non-CO₂ greenhouse gases, and aerosols. Despite this substantial progress, uncertainties remain. A particularly large uncertainty in radiative forcing is due to the response of clouds, the interaction of aerosols with clouds, and cloud-chemistry interactions. Recent observational campaigns and progress in modelling cloud microphysical and chemical processes suggest that the AR5 may be in the position to focus attention on **cloud-aerosol-chemistry processes** and interactions. This assessment will address the extent to which this influences climate sensitivity, the response of cloud cover, and the hydrological cycle. Other topics related to atmospheric composition and climate that have recently been gaining increasing scientific interest and that may need to be assessed further in the AR5 include the links between air pollution or air quality and climate as well as interactions between stratospheric ozone and climate.

Cross-Cutting Themes:

There are some themes or issues that cut across several or even all chapters in the WGI contribution, others that cut across WGI and another specific WG, and still others that cut across all three WGs. In the preceding paragraphs, examples of such cross-cutting themes can be identified. Some of these are treated in more detail below.

The **hydrological cycle** is one of the key elements in the consideration of climate change and impact. The hydrological cycle affects all subsystems in the climate, including the availability of water, and information is available from the distant past through paleoclimatic studies, from the recent past and the present through in-situ and satellite observations, and for the future through multi-model ensembles. It is thus a prime cross-cutting theme which requires to be addressed across all chapters of the WGI contribution to the AR5, and indeed potentially across all WGs. It should be considered whether a separate WGI chapter on this topic is timely, given that a Technical Paper on Climate Change and Water was published in 2008.

Paleoclimate analysis is a method to obtain unique information about past changes in the climate system. A comprehensive chapter on this topic was presented in the AR4. Since then, much new research has appeared which provides more information on abrupt changes, on modes of variability, and on rates of change. More information is also available on natural changes and impacts during the past millennia. The scoping process needs to explore different options regarding the incorporation of paleoclimate information in the AR5 (as a cross-cutting theme or in a separate WGI chapter).

Certain critical mitigation-related issues for WGI relate to **irreversibility and climate constraints on emission pathways** (including peaking scenarios, total cumulative emissions, etc), as well as the **climate's sensitivity** to "carbon emissions". Much information on this will come from models of reduced complexity and there will also be a substantial contribution in the AR5 from full earth system models. The outcome of a recent IPCC Expert Meeting on the Science of Alternative Metrics (April 2009) to compare the effect of emissions of different radiatively active agents on radiative forcing and climate has highlighted gaps in scientific understanding. There are indications that more research on the science of **alternative greenhouse gas metrics** will become available in the coming years and that addressing this as a theme cutting across all WGs is appropriate.

Contribution of Working Group II (May 8, 2009)

For the AR5, stakeholder needs for policy-relevant information are more focused, but also more diverse, than they were for past assessments. Increasingly, the world's nations are demanding information that can support good policy decisions. Information about managing risk, making smart investments, and adapting to climate changes that cannot be avoided will be central components of future discussions. As the world's nations sharpen their focus on dealing effectively with the challenges of climate change, their needs progressively emphasize decision support, in the context of the full range of impacts, sectors, and regions, including interactions with other stresses.

Climate science is advancing rapidly, with a vast range of new knowledge concerning diverse aspects of impacts, adaptation, and vulnerability. Much of the new knowledge is in the traditional peer-reviewed scientific literature but much is not. Taking advantage of the new knowledge that is outside the traditional scientific outlets, including grey literature and traditional knowledge, will require sophisticated approaches and careful management, if this information is to meet the exacting standards of the IPCC. Effectively assessing information from diverse kinds of sources and varied regional, cultural, and economic perspectives will require approaches for identifying common principles and developing shared frameworks.

In order to broadly support stakeholder needs for policy-relevant assessment, the IPCC needs to synthesize knowledge on a wide range of issues in the AR5. Still central to the challenge are sectoral and regional impacts and vulnerability, plus information on observed and potential adaptation. In the AR5, new knowledge and new demands from stakeholders will set the stage for increased emphasis on a number of key topics and cross-cuts. These include:

- Framing the assessment of impacts in the context of risk management, where risk integrates consequence and probability.
- Assessing impacts of climate change in the context of other stresses, including stresses related to development status, economic base, infrastructure, geopolitical setting, land use, and ecological resources.

- Expanding the coverage of adaptation to include more information on consequences, experiences with mainstreaming, and decision support for adaptation strategies.
- Integrating impacts, adaptation, and mitigation with common currencies and common frameworks.
- Broadening the range of assessed impacts, with increasing coverage of oceans, security, indirect impacts, interactive impacts, and impacts related to extremes and disasters.
- Exploring the interaction of climate change with development.
- Better integrating climate science with climate impacts, especially in areas where the impacts can provide strong feedbacks to the climate system, including land and ocean carbon cycles, exchanges of other greenhouse gases, and ice.
- Assessing new impact studies based on AR5 climate, including multi-model comparisons and validation against observations.
- Improving the treatment of regional aspects of climate change, reducing redundancy with sectoral chapters and increasing integration of climate science, impacts, adaptation, and vulnerability.

All of the new information should, to the maximum extent possible, be presented and organized to support good decisions, decisions that will need to integrate diverse perspectives and deal appropriately with uncertainty and the full range of possible impacts.

Managing the risks of climate change

The AR4 Synthesis Report concluded that responding to climate change involves an iterative risk management process that includes both mitigation and adaptation, taking into account actual and avoided climate change damages, co-benefits, sustainability, equity, and attitudes to risk. Decision-makers need an assessment of current practice at local, national, regional, and international scales to identify best practices, opportunities to increase climate resilience, and approaches to overcome barriers to implementation.

Effective support for good decisions depends on extracting information from the full range of possible outcomes, weighted by probability. Taking advantage of the information content across the entire probability distribution of possible outcomes presents great challenges, but the scientific community is increasingly capable of presenting this kind of information, and the stakeholder community is increasingly ready to act on it. All of the components of risk management need to be assessed and communicated, if stakeholders are to obtain the maximum possible value from this approach.

An effective assessment will require assessing not only the peer-reviewed published literature, but also grey literature published by governments, NGOs, and others that detail experiences with designing, implementing, and evaluating options for managing risk.

Interacting and multi-sector impacts

The risks of climate change have new dimensions, complications, and constraints when they occur in the context of other stresses. Other stresses can be additional consequences of climate change, or factors totally independent of climate change, such as infrastructure, economic development, geopolitical setting, population pressure, land use, or ecological resources. In some cases, effective routes to adapting to climate change may involve addressing some of these stress factors. In others, it may be useful to think about adapting simultaneously across several stresses. Many of the most challenging regional impacts of climate change emerge from interacting stresses. Effects of multi-factor, interacting stresses on people, societies, infrastructure, industry, and ecosystems can be complex and difficult to untangle, but the scientific community is increasingly stepping up to the challenge of providing policy relevant information.

Adaptation

Decision-makers are asking for the AR5 to explicitly explore adaptation at sectoral, regional, and temporal scales. Doing so will require consideration not only of impacts resulting from the most likely climate scenarios, but also impacts arising from lower-probability and higher-consequence events, as well as the consequences of proposed policies and measures. Questions are being asked about effective and efficient mechanisms for addressing medium to low probability and high impacts events. Further understanding is needed about opportunities to address the barriers and limits of adaptation, partly because effective adaptation measures are highly dependent on specific geographical and climate risk factors as well as institutional, political, and financial constraints.

Integrating impacts, adaptation and mitigation

The global experience with a changing climate is rapidly cementing the realization that response strategies will need to include both mitigation and adaptation, in a setting where not all impacts are avoided. In this kind of environment, it is important to create a uniform context for considering investments in and consequences of investments in both adaptation and mitigation. Working Group 3 is intensively focused on the costs and benefits of mitigation. It is increasingly clear, however, that this kind of analysis can be greatly enriched with more knowledge on the costs and benefits of adaptation, and on the costs of the impacts. For some kinds of adaptation and for some classes of benefits, the literature on costs is well established. For non-market sectors like biological diversity, the scientific literature is less helpful. Part of the problem is that non-market resources are difficult to monetize. This does not mean, however, that they cannot be evaluated. One of the challenges for the AR5 will be building on the existing valuations in a way that allows for the emergence of common metrics and support for multi-sector analyses.

The impacts of climate change will vary regionally. Aggregate costs can hide disparate impacts. A small impact of climate change on national accounts could result from significant impacts in one region and limited impacts in other. Better understanding is needed of not only the aggregate costs, but also regional and sectoral specification of costs and how they might vary across temporal scales. There also is interest in better understanding how to incorporate non-market impacts when calculating the costs of climate change.

Reducing current and projected impacts of climate change requires effective climate policy that involves a portfolio of adaptation and mitigation actions, with the decisions taken at different governance levels. Better understanding is needed of how creating synergies between adaptation and mitigation can increase the cost-effectiveness of actions. The AR4 concluded that it was not yet possible to answer the question as to whether investment in adaptation would buy time for mitigation. Decision-makers want to identify trade-offs and synergies between adaptation and mitigation.

The AR5 offers the opportunity to better integrate the assessments of adaptation and mitigation between WGs II and III at the regional level, as well as to assess co-benefits of reducing GHG emissions for health and other sectors.

Broadening the range of assessed impacts

Over the last several years, science on climate impacts has developed rapidly, and progress is continuing. For the AR5, the scientific literature on a range of impacts, not covered in detail in the AR4, should be ripe for a careful assessment. One area is impacts of extreme events and weather-related disasters. The risks of and responses to extreme weather events will be the focus of a Special Report to be completed in 2011, and the Special Report should feed effectively into the AR5. Another area with abundant new science is the oceans. New science on acidification, thermal tolerance of fish and other ocean organisms, food webs, and nutrients is advancing rapidly, and the opportunity for assessment is solid. A third area with rapidly developing science involves climate and security. Climate-security issues range from disputes over resources to population migration to rapid distribution of emerging disease. In each of these areas, the literature is rapidly becoming mature enough to support an assessment. A final area where expanded discussion by the IPCC

can make a contribution concerns indirect impacts of climate changes in remote locations, something that might be called an impact teleconnection. In food security, this kind of teleconnection is reasonably well understood. The maturity of the science for other sectors should be tested.

The range of observed impacts is also expanding rapidly, with many of the multi-year data sets finally reaching the stage where patterns and sensitivities are beginning to emerge. Time series from satellites launched around 2000 fit into this category, as do data from many manipulative global change experiments. Finding a way to assess other kinds of time series presents additional challenges, especially for series not published in the mainstream scientific literature.

Understanding the interactions between climate change and development

The AR4 concluded that climate change will affect the ability of many nations to achieve sustainable development pathways. Enhancing society's response capacity through the pursuit of sustainable development is therefore one way of promoting both adaptation and mitigation.

Understanding of how development planners incorporate information about climate variability and change into their decisions is limited, thus limiting the integrated assessment of vulnerability. Adapting to climate change and promoting sustainable development share common goals and determinants including access to resources (including information and technology), equity in the distribution of resources, stocks of human and social capital, access to risk sharing mechanisms, and abilities of decision-support mechanisms to cope with uncertainty. Despite this, some development activities exacerbate climate-related vulnerabilities.

A significantly larger literature base (peer-reviewed and grey literature) will be available for the AR5, providing an opportunity to explore what has been learned about the challenges and benefits of mainstreaming adaptation into development planning.

Integrating climate science and climate impacts

The distinction between impacts of climate change and drivers of future climate change is frequently blurry. An increase in wildfires might be attributed to climate change, but an important consequence of the increase could be the release of CO₂ and other GHGs to the atmosphere, amplifying the global warming. Similarly, the disappearance of sea ice has important consequences both for shipping and for reflecting shortwave radiation from the surface.

In past assessments, the distribution of impacts and feedbacks between Working Groups 1 and 2 wasn't always obvious, with some of the feedbacks discussed in the report of WG2, and some of the impacts discussed in the report of WG1. For the AR5, finding a way to use the overlap to strengthen messages and emphasize coordination should be a top priority.

New impact studies based on AR5 climate

New initiatives to develop and explore the AR5 climate are already underway. Several groups are making progress on the challenge of developing new impacts science based on the AR5 climates. The plan is that this new impacts science will involve both prospective and paleo approaches. It should also involve formal multi-model intercomparisons as well as careful validations against observations.

Regional aspects of climate change

Regional aspects are fundamental to a useful assessment of climate science, impacts, adaptation, and vulnerability. Regions vary in important determinants of vulnerability, and they often (but not always) share constraints and opportunities from climate similarities, socioeconomic status, infrastructure, etc. In addition, regions may choose to develop coordinated policies. Finally, regional stakeholders could benefit from an integrated treatment, with the climate components of interest to them spanning the topics typically covered by Working Groups 1 and 2.

Designing a report that does justice to the importance of the regional information, while also avoiding redundancy and errors presents serious challenges, especially if the sectoral and regional chapters are in the same volume. On the other hand, producing a separate volume entails a massive extra effort by at least 2 of the working groups and could cut into the quality of the AR5.

A way forward on regional chapters should acknowledge their fundamental importance and the value of presenting the information in an integrated way. It should also acknowledge the diversity of ways that the regions could be determined.

Decision-makers are asking if there is sufficient science to assess these reasons for concern at regional scales, to inform the modification of current policies and the implementation of new measures to increase resilience to projected impacts.

Contribution of Working Group III (June 22, 2009)

1. Rational and Background

There is an on-going debate that the impacts of climate change have been underestimated. At the same time, economists argue that the costs of avoiding impacts of climate change might be underestimated by previous studies because they have not taken into account the limited availability of technologies and delayed participation. The uncertainties surrounding mitigation costs and impacts of climate change call for a more integrated assessment of the contributions of mitigation and adaptation, respectively. The AR5 will benefit from close cooperation between the three working groups: WGI will further reduce the remaining uncertainties about the causes of climate change. WGII and WGIII will anticipate challenges by the scientific community and by policy-makers. The following key themes need to be the main focus of WGIII in order to deliver decision-relevant knowledge for stakeholders in business, civil society and policy:

Stabilization Targets and Costs: The costs of mitigation targets and related adaptation needs have to be assessed in an integrated manner despite the fact that mitigation and adaptation options are uncertain. We do not know when and where particular impacts, technologies or institutions will occur – especially local impacts – and which technologies or institutions will develop. These uncertainties have a crucial effect on the design of mitigation and adaptation strategies. The portfolio of mitigation options has to be tailored to sectors and regions. An assessment of sector-specific costs is crucial for a better understanding of the barriers of implementation. In addition, the transformation towards a low-emission economy is to be specific for different regional aspects taking into account international trade and development patterns.

Sectors, Infrastructure and Land-use: The creation of an appropriate infrastructure is at the heart of sustainable development as most infrastructures are not exclusively dedicated to mitigation of or adaptation to climate change. Instead, they are built to serve human needs such as housing, energy, water, transport, communication etc.

Equity, Fairness, Sustainable Development and Life Style Changes: Problems of collective action, or public good problems that may overlap with various parallel challenges, can only be solved if the solution is considered to be fair and based on adequate equity principles. In general, the equity principle has to be applied to inter- and intra-generational justice as a prerequisite for sustainable development as well as lifestyle changes.

International Cooperation and Global Finance: The management of mitigation and adaptation options has to deal with a multitude of collective action problems. The climate challenge consists of many of these problems. Up to now, climate economics and policy analyses have had a strong emphasis on policy design. However, institutional aspects and capital market issues deserve equal attendance.

2. Issues to be Addressed Within the AR5 Scoping Meeting

2.1 Stabilization Targets and Costs

A reasonable risk assessment is required to find an acceptable division of labour between adaptation and mitigation. The AR4 largely neglects to attempt an integrative view on the risks of climate change impacts and of various mitigation options. On the one hand, scientists argue the rational of different stabilisation levels that are necessary to avoid dangerous climate change. On the other hand, economists and political scientists call for a more careful assessment of the mitigation costs. Therefore, the risks and costs of climate change impacts and of different mitigation options (e.g. biomass, nuclear energy or wind energy) need to be identified and discussed.

Any stabilization level corresponds with a respective level of adaptation needs. The less ambitious the stabilization level, the larger the negative impact of climate change requiring an integrated analysis. Even a successful stabilization of atmospheric CO₂-concentrations at low levels would require adaptation strategies in industrialized and developing countries due to the degree of climate change that corresponds to the stabilization commitments. However, the economic costs and demands to the social and physical infrastructure of these impacts are largely unsettled to date.

2.1.1 Robust Mitigation Strategies in a Wide Range of Stabilisation Scenarios

The economic, social, and technical prerequisites, consequences and implications of different *mitigation strategies* need to be assessed. Although initial scenarios were developed that demonstrate how different stabilization levels can be achieved, a new generation of scenarios is required. An assessment is needed that has evaluated the risks of different mitigation options, precluding an integrated assessment of the different choices available (e.g. extensive biomass use or CCS). While the AR4 analysed the potential and the costs of different mitigation options, suitable systematic analyses are missing. These mitigation technologies need to be embedded in an economic, ecologic and also societal context that only then allows for a *risk assessment* of these strategies.

Most cost estimates of stabilization scenarios to date have assumed a “perfect world” with respect to the range of available technologies and to the soundness of the international regime. That is, it is assumed that the whole range of relevant technologies will be available in time and that all relevant countries participate in an international climate policy regime. In reality, however, this may not be the case, having implications for the costs of stabilization and, more generally, for the achievability of the different stabilization targets e.g. of the different Representative Concentration Paths (RCPs). This issue of second best scenarios is particularly important for stabilization at low levels as the significance of technological and socioeconomic prerequisites rise with increasing ambitions for stabilization levels, and as low stabilization scenarios have been merely assessed in AR4.

Any stabilization level corresponds with a respective level of adaptation needs. The less ambitious the stabilization level the larger the negative impacts of climate change requiring an integrated analysis. Even a successful stabilisation of atmospheric CO₂-concentrations at low levels would require adaptation strategies in industrialised and developing countries due to the remaining climate change that has been committed to. However, the economic costs and demands to the social and physical infrastructure of these impacts are largely unsettled to date. The development of robust *adaptation strategies* requires an adequate understanding of the risks and uncertainties of social systems. Studies on regional impacts are essential for the adjustment to this residual climate change as well as the evaluation of climate damages. When estimating climate damages, monetary evaluation methods as well as methods that can identify damages that cannot be expressed in changing market prices should be used.

It is equally important to combine strategies of mitigation and adaptation to climate change with measures to reduce poverty and address development problems in a more coherent manner. This requires a stronger participation of developing country economists and development economists who have so far hardly participated in this discussion.

2.1.2 Risk Perception

The reports of the IPCC are implicitly based on the hypothesis that the climate problem is perceived in the same or at least in a similar way all over the world. However, this is not the case. The perception of the risks of climate impacts and of possible solution strategies is subject to different cultural backgrounds. Therefore, a stronger dialogue with the social and cultural sciences is required in WGIII to be able to assess the climate problem as a global problem in spite of existing social and cultural differences.

2.1.3 How to Assess Scenarios (incl. Metrics)

In the future, the IPCC should assess and communicate risks in such a way that civil society, policy-makers, and business can discuss practicable and consistent alternatives and include them in the collective decision-making process. Hence, the IPCC needs to strengthen its position of an "*honest broker*" that presents policy-relevant alternatives without prescribing decisions for politics, civil society, and business. The exploration of available alternatives should be supported by *expert workshops* that would allow the business community and civil society to share their knowledge with the scientific community. However, the honest broker role is only possible if WGIII explores multiple scenarios for managing the climate problem. Instead of emphasizing one pathway to a low-carbon economy, it should emphasize to policy-makers that there are many ways. Therefore, WGIII should also internally explore self-consistent extreme scenarios (e.g. scenarios with an extreme expansion of nuclear or renewable energies) and assess their social, economic and technical implications. This seems to be a much more effective way to communicate risks to policy-makers as it encourages adequate thought surrounding distinct alternatives and variable representations of the problem. Forming a consensus about policy options is a task for policy-makers - scientists should try to explore the implications of scenarios in a consistent way.

In addition, WGIII should explore not only extreme scenarios enabling policy-makers to discuss alternatives, but should also provide an assessment of the implications of different scenarios. This task is twofold: First, an assessment of mitigation costs and strategies is based on sometimes hidden assumptions about welfare metrics, ethical values, parameters and so on. Second, each portfolio of mitigation options has social and economic consequences that are not captured in quantitative models. Important examples include the extensive uses of biomass, CCS, or nuclear power, which omit crucial risk categories that are highly relevant for policy-makers.

The particular aim will not be to increase the range, but to improve the understanding of the mechanism behind modeling concepts, their results and their cost estimates. Different models rely on different assumptions and produce different cost estimates. This is particularly true for the two groups of bottom-up and top-down models. Whereas the former are particularly rich in the representation of technologies, the latter group incorporates economic feedback of policies. Therefore, the technology assumptions of the different models shall be compared with each other in order to arrive at a common metric.

2.2 Sectors and Infrastructure

The potential of a country or region for adaptation and mitigation is determined by various socio-economic and technological factors, including the patterns of its integration into the world economy. Thus boundary conditions, which are important and not yet sufficiently appreciated, will affect the resulting mitigation strategies. Integration into the world economy promotes an increasing degree of urbanisation that in turn requires a change in traffic, housing and energy infrastructure – a development that poses an enormous challenge especially for developing and newly industrialising countries.

Since investments in infrastructure in the next decades will determine the path for the rest of the 21st century, credible price signals for CO₂ are necessary. It will be important to avoid path dependencies for an emission-intensive infrastructure planning – especially with regard to the general longevity of carbon-dependant assets. The impacts of climate change on the dynamics of urbanisation also deserve stronger notice: Here, the loss of agricultural land and the effect of extreme events on infrastructure should come to the fore. Further, it has to be clarified how the city-land ratio will change under conditions determined by adaptation and mitigation strategies. This issue in particular shows that adaptation and mitigation can no longer be sensibly separated, but

rather need to be considered from an integrated perspective. For some topics, such as land use or infrastructure and housing, the link needs to be explicitly considered.

Infrastructure policies are at the heart of sustainable development, representing the nexus of mitigation and adaptation in practice in that infrastructures are built to provide services that significantly contribute to sustainable development. This goes hand in hand with the necessary long-term view. Hence, this selection of topics is specifically suitable to further promote the integration of adaptation and mitigation, while at the same time taking regional differences into account. The analysis would include a sectoral approach with references to energy supply, industry, transportation, residential and commercial sectors, agriculture and forestry, as well as waste management.

2.3 Equity, Fairness, Regional Sustainable Development and Life Style Changes

Both inter- and intra-generational justice have strong links to sustainable development. Intergenerational justice refers to equity between generations. The debate on time preferences and on investments in mitigation and adaptation can only be understood in the context of intergenerational justice. However, assessing the distribution of mitigation costs and impacts for the poor requires a careful discussion of intragenerational justice. It is equally important to combine strategies of mitigation and adaptation to climate change with measures to reduce poverty and address development problems in a more coherent manner. This requires a stronger participation of developing country economists and development economists, who have hardly participated in this discussion to date. A stronger focus of the IPCC on poverty and development problems as a crosscutting issue is therefore required.

The necessity to better include development issues also points to the regional dimension of climate change: There is a considerable need to compare analyses on the effects of climate policy in different world regions as these will enable informed decisions based on equity and fairness principles while also adequately considering the aspect of development. In a series of country case studies ("Regional Climate and Energy Policy Reviews"), the following aspects should thus be assessed:

- Emission trends and projections, energy system characteristics, energy intensity, carbon intensity, emissions beyond the energy sector;
- Availability of fossil energy resources and the potential to use renewable energies;
- Mitigation potentials and costs;
- Exposure and adaptability to climate change;
- Climate-policy relevant positions and basic institutional conditions; and
- Assessing development according to reasonable indicators for sustainable development.

The regional assessment would refer to socio-economic regions (e.g. industrialised countries, important emerging economies, exporters of fossil energy sources and other developing areas) as well as geographical regions (i.e. integration initiatives), and, as appropriate, the availability of regional information would be considered. In addition to bottom-up-approach models, top-down-approach regionalised macro-economic models should be followed. This would allow a determination and comparison of the welfare effects of international climate policy of individual states by taking account of the role of international trade.

Significant emission reductions will also require changes in lifestyle. This may include a change in valuation of the kind and level of consumption considered necessary for wellbeing (e.g. car size). The ability to make changes in lifestyle also interacts with infrastructure policies. The ability to use public transport instead of cars, for instance, depends on the very existence of the related infrastructure.

2.4 International Cooperation and Global Finance

2.4.1 Collective Action Problems

The cost estimates of the IPCC depend on the crucial assumption of an existing global carbon market or a global carbon tax. Both assumptions define a benchmark for a first-best optimum but are politically unrealistic. There is broad agreement that a sound climate policy can avoid dangerous climate change without prohibitive economic costs; that is, *if* it can resolve the public good problem. However, with good reason it is often emphasised that the climate problem is the greatest public good problem of humankind, the correction of which will cause considerable institutional costs. It is increasingly doubted that an international agreement to reduce worldwide emissions can be reached in a timely fashion.

The international discussion of global climate-policy options has furthermore revealed that the climate problem does not consist of a single public good problem but of a multitude of collective action problems: An extensive use of biomass would for instance require additional international agreements, e.g. on forest protection or food supply, and an extensive use of nuclear energy based on fast breeder reactors would demand international agreements on proliferation control. Cap and trade systems could be complemented by international technology cooperation, which has additional co-benefits for other sectors. Additional adaptation measures of developing countries also call for collective action that cannot be performed by the markets alone and that is closely related to the topic of development. These overlapping public good problems make the management of climate change more complex to analyse, but also give rise to enhanced enforceability of effective climate change policies through linking issues. As recent studies have shown, issue linking might increase the probability that free rider behaviour can be limited to an acceptable extent. An assessment of how these links have to be designed to manage the climate public good problem should be on top of the research agenda.

Competitiveness, Energy Security, Growth and Climate Policy

Politicians and other stakeholders are confronted with competitiveness effects of emission-intensive industries, the security of energy supply, and the economic consequences of climate policy for growth and employment. AR4 has made a first step here. However, a methodologically convincing analysis of the impacts of mitigation strategies for different sectors (transport, electricity, industry, heat market, housing, agriculture, health) within the different temporal timeframes still needs to be accomplished. The effect on employment and the sectoral winners and losers is decisive for the success of any climate policy. Moreover, energy security has become a prime concern of foreign policy and geopolitical strategies in China, the USA and Europe. Many decision makers see energy security as a more important challenge than climate change. A realistic assessment is needed to explore the trade-offs, but also the potential synergies and side-benefits. Apart from quantitative modelling (top-down), the technical and institutional limits of emission mitigation strategies should be complemented by qualitative analyses (bottom-up). In particular, sector-specific policy instruments should be analysed. Energy efficiency and conservation are among the desirable options to address in policy as both are equitable and sustainable.

Technological Change and Technology Transfer

Inducing innovation is a long-term challenge. Unfortunately, the literature is quite inconclusive regarding what kind of policy instruments should be applied in the area of climate and energy policy. This discussion must go beyond comparing taxes and quantities. It seems much more promising to think about hybrid solutions, combining taxes, quantity instruments, subsidies and standards in an innovative way. Policy-makers are keen to apply hybrid solutions. However, the theoretical basis for this application has to be strengthened.

Technology transfer remains a challenge. The Clean Development Mechanisms (CDM) is regarded as an important vehicle, but so far it has not performed satisfactorily and a general revision of this instrument is under discussion. In recent years most of the multilateral development finance institutions (World Bank Group, Regional Development Banks) have introduced some financing and technical assistance facilities for renewable energy, energy efficiency, and carbon trade. These instruments need to be evaluated and enhanced. Intellectual property rights (IP) as private rights promote innovation and the dissemination of knowledge on the one hand, but make access to

knowledge more difficult or costly on the other hand. In any policy context, including climate change, a balance between the protection of IP rights and the promotion of public objectives, such as the transfer of technology, is necessary. Therefore, AR5 needs an assessment on how to improve technology cooperation and technology transfer between Annex I and Non Annex I countries.

2.4.2 Climate Policy Instruments, Global Finance, and Risk Management

For policymakers, the short-term distribution of costs is much more important than the long-term reduction of average mitigation costs. Therefore, policymakers would like to be informed about the short-term implications of long-term policies. In addition, the private sector is interested in the long-term implications of short-term policy instruments. Long-term investments in new technologies will only be feasible for the private sector if it can rely on credible long-term targets. As is well known from macro-economic policy, a sequence of short-term policy targets can be time-inconsistent in the sense that policymakers may have an incentive to change their targets over time, which will prevent firms from making the necessary innovations for successful and efficient transformation of the energy system. It is an unresolved question of what kind of policy instruments are needed to encourage long-term and risky investments like in CCS or renewable energies.

Sources of Finance and Capital Market

Large parts of the additional investments will have to take place in non-OECD countries. Developing countries, however, will not be able to bear all the financial needs. New sources of finance need to be explored. One possibility would be to auction part of the international emission permits. Another would be a stronger engagement of the private sector.

Climate change effects directly impact several branches of the insurance sector; some are in danger of facing extraordinary losses. A trend towards more risk-averse policies already exists, e.g. insurance is limited or unavailable in areas where large floods have occurred in recent decades, affecting industry, households, and governments. Higher risk premiums increase expenses for local economies. In developing countries the use of insurance is far lower than in developed regions due to a lack of financial assets. Thus, developing this sector in those regions can provide a suitable adaptation strategy, e.g. with premiums paid by NGOs in cases where neither insured parties nor governments are able to pay. These issues were only briefly touched upon in the AR4, and need to be developed further.

A major shift of economy-wide investments away from carbon-intensive industries towards emerging "green" sectors will have to take place in order to cope with climate change (see infrastructure). However, adaptation and mitigation do not invariably compel additional expenditures. For example, efficiency gains and demand reductions bear the potential to substantially offset investment needs in low-carbon technologies. That is, emission reduction policies do not jeopardize development but put it on a different, more sustainable path (see infrastructure).

In order to trigger such a behavioural shift in the private sectors, which are to bear large fractions of the transition, effective political incentives will be inevitable, leading to the issue of investment climate and risks from regulation. Especially uncertainties about future developments (e.g. of carbon prices) need to be eliminated to reduce risks.

Carbon Pricing

Carbon pricing will be among the most important measures to mainstream emission mitigation in the rest of the economy. Therefore, instruments that attach a price to carbon will be of particular relevance. Policy developments in this area have been very dynamic in the last years with major improvements in the European carbon trading scheme and the arrival of a common scheme in the Northwestern United States.

2.4.3 Key Elements of an International Regime

By the time of the WG III's contribution to AR5, the agreements coming out of Copenhagen will have been negotiated and will need to be assessed. As already mentioned, the climate problem comprises a multitude of public good problems. This makes the solution to the problem more complicated to analyse but it might also expand the space for reasonable solutions and compromises. This becomes particularly apparent in the design of an adequate international climate

policy and sound energy security approach. As a consequence, the *architecture* of a future *climate regime* needs to integrate the following components:

- Equity, poverty reduction, and sustainable development considerations;
- Pricing of GHG emissions through emissions trade and possible links to energy security and competitiveness require a careful analysis;
- Implementation of a technology policy including provisions to pool innovations and to encourage first-movers;
- Fair distribution of emission rights among the participating countries as well as compensation of climate damages by the polluter;
- Provision of an infrastructure to finance investments in climate protection, mostly for developing countries;
- Establishment of political instruments in mega cities and developing young cities, for instance congestion charges or incentives for low-emission housing;
- Control of global land use, especially implementation of incentives to avoid tropical deforestation taking into account possible links to biodiversity and food security;
- Assessment of geo-engineering as a public good: Some scientists argue that geo-engineering options which directly control the radiation budget of the earth could be agreed upon by a smaller number of countries and would thus involve considerably lower institutional costs than an agreement on a world-wide reduction of CO₂ emissions;
- Adaptation fund: The design of an adaptation fund will be crucial for the involvement of developing countries.

International regime architecture needs to take into account the uncertainties of the climate and economic systems when structuring its policy instruments. These instruments should serve to catalyze climate protection paths that are robust against uncertainties of the climate system (e.g. climate sensitivity) as well as the socio-technical system (e.g. technical progress in renewable energy sources). Here, it will be more important to provide a suitable scientific instrument that allows the systematic determination of possible trajectories for diverse normative settings than to anticipate political negotiations.

Depending on their structure, climate-policy agreements could have considerable geopolitical implications that require thorough analyses. If such analyses are not carried out, an international agreement for climate protection will not be implemented because it might not be in accordance with the interests of nations pursuing economic growth and energy security. The increasing utilisation of brown and hard coal in the USA and China is attributable to the desire to reduce dependence on oil and gas imports. The question on how an ambitious climate policy will change international labour division by shifting the importance from oil and gas producers to those of coal (China, India), biomass (Russia) and solar energy (North Africa, South America) has not yet been closely examined.

Furthermore, the emergence of numerous climate change initiatives by non-nation state actors in cities and regions (as well as other stakeholders at civil and/or corporate levels) seeking to reduce emissions of greenhouse gasses may have significant implications for climate change governance. As such, initiatives may offer a means through which international goals could be achieved, in that they contribute to the likelihood of success negotiating mitigation targets. A thorough understanding of these initiatives would establish a local basis for assigning responsibilities, coordinating efforts, and promoting equity, accountability, and qualitative participation in the global management of climate change.

3. A possible Structure of AR5 WG III

1. Stabilization Targets and Costs
 - 1.1. Metrics, Top-Down and Bottom-Up
 - 1.2. Stabilization Targets, Related Impacts and Adaptation
 - 1.3. Second-Best Scenarios
 - 1.4. Uncertainty and Risk
 - 1.5. Prerequisites: Technologies, Socio-Economic Conditions

2. Sectors and Infrastructure
 - 2.1. Infrastructure
 - 2.2. Sectoral Mitigation Potential
 - 2.3. Policy Measures
 - 2.4. Land-Use Change

3. Equity, Fairness and Regional Sustainable Development
 - 3.1. Poverty
 - 3.2. Justice and Fairness and Sustainable Development
 - 3.3. Risks and Opportunities of Mitigation Strategies

4. International Cooperation and Global Finance
 - 4.1. Collective Action Problems
 - 4.1.1 Competiveness, Energy Security, Growth and Climate Policy
 - 4.1.2 Technological Change and Technology Transfer
 - 4.2. Climate Policy Instruments
 - 4.2.1 Emissions Trade
 - 4.2.2 Taxes
 - 4.2.3 Standards
 - 4.3. Global Finance, Risk Management and Climate Change