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## **WORKING GROUP II CONTRIBUTION TO THE IPCC FIFTH ASSESSMENT REPORT (AR5)**

### **Background information**

(Submitted by the Co-Chairs of Working Group II  
on behalf of the Working Group II Bureau)

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## **The Working Group II contribution to the IPCC Fifth Assessment Report: Context and background for the outline**

(C. Field, V. Barros, K. Ebi, 1 October 2009)

### **Overview**

The overall structure of the WGII contribution to the AR5 is parallel in most respects to the WGII contribution to the AR4. The contribution consists of a number of global chapters focused on sectors, global chapters focused on multi-sector topics, and regional chapters that provide a synthesis of climate-change issues at the regional scale. Although the structure is similar to that of the WGII contribution to the AR4, the WGII contribution to the AR5 builds on new knowledge to make several important advances. In particular, the assessment represents an advance in terms of:

- Improved integration of 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, including multi-model comparisons and validation against observations.
- Broadening the range of assessed impacts, with increasing coverage of oceans, security, indirect impacts, and interactive impacts.
- 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.
- Building on the conclusions of the Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation to provide a more comprehensive and detailed assessment of the role of extremes and disasters.
- Framing the assessment of impacts in the context of information to support good decisions, with an emphasis on assessing and managing risk, where risk integrates consequence and probability.
- 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, emphasizing not only the costs of adaptation and mitigation but also the benefits of the avoided damages.
- Exploring the interaction of climate change with development.
- Improving the treatment of regional aspects of climate change, reducing redundancy with sectoral chapters and increasing integration of climate science, impacts, adaptation, and vulnerability.

The outline includes 20 global/sectoral chapters and 10 regional chapters. As part of a comprehensive effort to enhance the relevance of the regional chapters, the WG2 assessment will be published in 2 parts, with part A containing the global and sectoral chapters, and part B containing the regional chapters. A single summary for policymakers and a single technical summary will cover both parts of the assessment.

The motivation for the additional chapters comes from three considerations. First, the WGII contribution to the AR5 addresses key sectors and systems that were largely omitted from the WGII contribution to the AR4. New chapters address oceans (one chapter in the global/sectoral section and one in the regional section), human security, and livelihoods and poverty. Second, several new chapters emerge from the need to provide expanded coverage of key topics. The assessment includes four chapters focused on adaptation (increased from 2 in the AR4) and three chapters on

human settlements and economic activities (increased from one in the AR4). Third, the assessment includes two new chapters that set the stage for the other chapters. These introduce concepts and orient readers to key themes, with one chapter introducing the global and sectoral material and another chapter introducing the regional material.

Building on the experience from the AR4, the WGII contribution to the AR5 places a strong and consistent priority on effective coordination among the working groups. This is being implemented through joint planning and management of expert meetings and IPCC workshops, ongoing coordination at the TSU and author level on key topics where perspectives from more than one working group are relevant, and engagement of lead and contributing authors with experience and skills to make them effective in WGI or WGIII as well as WGII. The narrative on the contents of the assessment (below, pages 4-10) highlights a number of the specific instances where effective coordination with WGI or WGIII is critical.

## Structure

The global/sectoral chapters are organized into six major thematic clusters:

1. Context for the AR5
2. Natural and Managed Resources and Ecosystems, and Their Uses
3. Human Settlements, Industry, and Infrastructure
4. Human Health, Well-Being, and Security
5. Adaptation and Development
6. Multi-Sector Impacts, Risks, Vulnerabilities, and Opportunities.

The thematic clusters provide an organizational framework for the material and are intended to facilitate parallel handling of key themes across related sectors. The clusters also encourage authors to develop links among chapters, including chapters that span thematic clusters.

The outline for each chapter lists major headings only, except in a few cases where second order bullets are essential for communicating a chapter's core theme and direction. Because the chapters are very broad, the major headings are broad as well. Each major heading points to a direction for the assessment and is intended to open pathways to a range of topics. Major headings are not intended to be restrictive but should, instead, encourage author teams to think broadly about the most important topics to cover. In addition to the major headings listed, each chapter begins with an executive summary, and each chapter includes answers to a small number of carefully selected "Frequently Asked Questions".

All of the sectoral and regional chapters take a related approach to core elements of the assessment. In the outline, these core elements are listed as *[Context]*. The context includes elements related to observed and projected impacts, as well as the economic, social, and ecological context for the impacts. The context includes an assessment of vulnerabilities, adaptive capacity, options for evaluating and managing risks, research and data gaps, and case studies. Rather than repeat all of these core elements in the outline of each chapter, the common elements of the context are listed at the start of the outline, and *[Context]* in the bullets for each chapter refers to the full set of topics listed in the *[Context]* section at the top of the outline. For some chapters, the *[Context]* falls naturally within a single section of the chapter. For others, it spreads through several sections. All of the sectoral and regional chapters, however, address the full suite of topics listed in *[Context]*, including case studies, which will likely appear in every chapter.

The chapters that do not need to address the bullets in the *[Context]* block are the two introductory chapters to the global/sectoral section (because these chapters provide the framework through which literature will be assessed), the four chapters in the adaptation section (because these chapters' cross-sectoral focus builds on the sectoral and regional analyses in the other chapters), the three chapters on multi-sector impacts, risks, vulnerabilities, and opportunities (because these chapters' cross-sectoral focus build on the sectoral and regional analyses in the other chapters). Finally, the introductory chapter in the regional section also does not include the context because it is largely conceptual.

The assessment is structured so that the printed and online versions are complementary. The printed version will be submitted for approval by the IPCC Plenary, with the intention that the online version will include a number of enhancements, including (where appropriate) hot links to other chapters and other Working Group reports, hot links to references (with relevant controls on intellectual property), zoom-in capability on figures, and links from figures to underlying data. The portal to the online version will allow users to customize their access to the WGII assessment, organizing the chapters to facilitate efficient communication, thus enabling users to easily assemble information across all chapters on topics of interest.

## **Cluster by Cluster Background**

### **1) Context for the AR5**

The two chapters in this section provide the frameworks through which literature will be assessed in the rest of the WGII contribution to the AR5. Chapter 1, “Point of departure” briefly characterizes the purpose, process, and organization of the assessment, and it summarizes the relevant results of other assessments, including the WGII report from the AR4, the Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation, and the report of WGI for the AR5. Chapter 2, “Foundations for decisionmaking” introduces and explain key concepts used throughout the other chapters. This chapter emphasizes the prerequisites for making good decisions under uncertainty. The concept of risk is central, as is the concept that different stakeholders often use diverse approaches for valuation of impacts, adaptation, and vulnerability, over a range of temporal and spatial scales.

### **2) Natural and Managed Resources and Ecosystems, and Their Uses**

The five chapters in this section begin the detailed treatment of systems and sectors. The chapters address the systems and sectors most strongly connected with the natural world, including freshwater resources, land and freshwater ecosystems, coastal ecosystems, the oceans, and systems for producing, processing, and distributing food. Note that the term “ecosystem” is used in its broadest sense in the chapter titles, referring not only to the plants and animals but also to the soils, landforms, human infrastructure, and human activities. The chapters on land and freshwater, coastal, and ocean ecosystems consider the full range of climate-change impacts, adaptation, and vulnerability in these sectors, including impacts on biodiversity, carbon storage, economic activities, and human residents and visitors.

The assessment highlights “Freshwater resources” in Chapter 3. Topics to be addressed include precipitation, surface water, groundwater, runoff, snowpack, and glaciers, with an assessment of trends and projections, including both means and variability (links to WGI). The chapter also considers approaches to decreasing vulnerability to water shortages, especially in the context of multiple pressures on water supplies, and to changes in water-related extreme events (links to SR Extremes).

Freshwater resources are assessed in a separate chapter from freshwater and terrestrial ecosystems (Chapter 4) for two reasons:

- Water availability, the timing of water availability, and water quality are important issues now. With additional climate change, availability of safe water for human uses will be increasingly constrained, and will likely dominate the impacts of climate change in some areas.
- Climate change will interact with freshwater and terrestrial ecosystems through related and similar mechanisms. Some of these involve the reorganization of plant and animal communities; others involve human activities.

Chapters 4, 5 and 6 on “Terrestrial and freshwater ecosystems”, “Coastal ecosystems and low-lying areas”, and “Ocean ecosystems” constitute the core treatment of ecological and economic impacts, adaptation, and vulnerability in these critical systems, and links between terrestrial, coastal, and ocean ecosystems will be highlighted. All three chapters take a balanced approach to treating biodiversity, economic activities, infrastructure, and impacts on the people who use the systems, in

settings where climate change is one of several stressors. The assessment will include forests, dry lands (temperate grasslands, Mediterranean ecosystems, deserts, desert oases), tropical grasslands and savannas, mountains, polar systems, tundra, permafrost, lakes and river ecosystems, wetlands, mangroves, coral reefs, deltas, estuaries, lagoons, beaches, deep sea, benthic, pelagic, polar oceans, sea ice, sea mounts).

Chapter 4, on “Terrestrial and freshwater ecosystems”, assesses economically important areas, including forestry, biomass energy, and opportunities for carbon trading. For all chapters in this section, but especially for Chapters 4 and 6, it will be important to work closely with WGI to insure harmonized treatment of ecosystem components to provide strong feedbacks to global climate.

Chapter 5 on “Coastal ecosystems and low-lying areas” is one of the key places where the assessment treats sea-level rise and its impacts. This chapter examines impacts, adaptation, and vulnerability to sea level rise in plants and animals, economic activities, and other human endeavors. Providing an effective assessment of impacts, adaptation, and vulnerability to sea level rise requires an interaction with WGI that provides comprehensive information on the probability distribution of the amount and timing of sea level rise, changes in extremes, regional patterns, and wave action. Special challenges of building and operating infrastructure in coastal and low-lying areas is a theme, with care to minimize overlap between the way this material is treated here, versus in the chapters on urban and rural areas.

Chapter 6 on “Ocean ecosystems” is new in the AR5. It assesses the impacts of changes in ocean temperature, pH, and circulation in a comprehensive way. Including acidification with the other possible changes in ocean processes facilitates an integrated treatment, including consideration of stressors beyond those related to climate.

“Food systems and food security”, the topic of Chapter 7, increases the focus of the AR5 on food and under-nutrition, relative to the AR4. By structuring the material around the concept that food production, processing, storage, and distribution functions as a system, the chapter assesses food security in the context of the full range of stressors that interact with climate change. Interactions to be assessed include competition for land and water resources between food and energy production (link to WG3). This chapter considers all of the major food production systems, including cropping, grazing, and fishing. It assesses the impacts of climate change on both subsistence and industrialized systems, examining direct and indirect effects of climate change. In the AR4, food was treated in a chapter that also considered production systems for forests and fiber. New knowledge since the AR4, combined with an intensified global interest in food and under-nutrition, provides a strong motivation for a focus on food security.

### **3) Human Settlements, Industry, and Infrastructure**

The three chapters in this section assess impacts, adaptation, and vulnerability to climate change, considering the built environment in a way that parallels and supports the focus on the natural world in the previous section. Chapters on “Urban areas”, “Rural areas”, and “Key economic sectors and services” address the major components of the built environment. Part of the motivation for expanded coverage over the AR4 is the availability of new science on climate change and the built environment; part is the diversity of impacts, adaptation opportunities, and vulnerabilities across urban and rural areas and key economic sectors; and part is a response to calls for a structure that facilitates consideration of interactions between climate change and other stressors and interactions among sectors.

Chapter 8, on “Urban areas”, is the primary place where the assessment considers the vulnerability of urban infrastructure, urban heat islands, and the role of climate change in the process of urbanization. Special features of urban areas in specific natural systems, such as large river deltas, will be highlighted. Chapters 8 and 9 (“Rural areas”) address relationships among climate change, the resource base, the built environment, social capital, and opportunities for

development. Interactions between urban and rural areas, between rural areas and food production systems, and between urban areas and their economic base will be highlighted.

Chapter 10, on “Key economic sectors and services” focuses on the role of climate change in economic activities beyond agriculture and forestry. An examination of the impacts, adaptation, and vulnerability of transportation, electrical power, and communications technology makes the assessment relevant for the full range of economic activities. In addition, this chapter provides a platform for addressing the vulnerability to climate change of a wide range of industries and services, including tourism, manufacturing, and power generation. This chapter is one of the places where the assessment considers impacts of potential geoengineering strategies (link to WGIII).

#### **4) Human Health, Well-Being, and Security**

The three chapters in this section address human systems and sectors, complementing the nature-based systems and sectors in section 2 and the built-environment sectors in section 3. The three chapters in this section address “Human health”, “Human security”, and “Livelihoods and poverty”. “Human health” (Chapter 11) assesses the role of climate change in determinants of health and health outcomes, including direct effects of heat and mortality from climate-related extreme weather events (link to SR Extremes), infectious diseases, malnutrition, and impacts related to water availability or quality (link to WGI). The chapter on “Human security” (Chapter 12) addresses the social and cultural consequences of climate change. This new chapter provides the opportunity to assess the literature on the role of culture in vulnerability to climate change. It also assesses the evidence on the role of climate change in diverse aspects of security, ranging from food security to migration to international conflict. Chapter 13, on “Livelihoods and poverty”, is one of the places where the assessment focuses directly on interactions between climate change and development, considering effects of climate change on the prospects for reducing poverty, effects of responses to climate change on levels of poverty, and effects of investments in reducing poverty on prospects for managing climate change (link to WGIII).

Structuring the assessment with separate sections focused on the natural world (section 2), the built environment (section 3), and humans (section 4) provides an opportunity to conduct a detailed assessment, while emphasizing the connections among the sectors and systems. Throughout the assessment, important consequences of links among natural systems, between human and natural systems, and among human systems will be highlighted, both in the body of each chapter and as specific case studies.

#### **5) Adaptation and Development**

The four chapters in this section address adaptation and development issues that cut across sectors and regions. The assessment in these chapters are structured to complement the treatment of adaptation in the sectoral and regional chapters that address sector-specific and region-specific experiences with adaptation, opportunities for improving adaptation, constraints on adaptation, maladaptation, and interactions with development. The global treatment assesses the same issues in the context of multiple, interacting sectors, as is characteristic of many investments in adaptation and development, as well as lessons learned across adaptation and development activities in different regions and sectors.

The four chapters in this section take a stepwise approach to adaptation and development. Chapter 14, “Adaptation needs and options” sets the stage. It synthesizes the existing literature on needs and options for multi-sector adaptation and assesses the plans and tools for evaluating adaptation. This chapter develops the conceptual foundations for identifying co-benefits and maladaptation. This chapter will include case studies on adaptation experiences.

Chapter 15, on “Adaptation planning and implementation” addresses the nuts and bolts of adaptation, from planning through execution, to evaluation. This chapter considers the role of institutions, governance, options for finance, and development, at a range of spatial scales and for a range of objectives.

Chapter 16, on “Adaptation opportunities, constraints, and limits” assesses the rapidly expanding literature on the limits to adaptation, a critical theme for any serious consideration of adaptation/mitigation interactions. Topics to be addressed include settings where investments in adaptation to one kind of risk decrease or increase vulnerability to other kinds of risks, including risks that are independent of climate change. This chapter also assesses the consequences of mitigation investments on options for adaptation, focusing on mechanisms beyond competition for limited resources (link to WGIII).

Chapter 17, on “Economics of adaptation” assesses formal and conceptual studies on the economics of adaptation, examining detailed studies that address costs of adaptation, the benefits of avoided damages, and levels of residual damages (link to WGIII). It considers economics using cost-benefit approaches as well as alternatives, including, for example, criteria based on Rawls’s theory of justice. The chapter also addresses the interface between the economics of adaptation based on standard currencies and quantities that are typically outside market economics. It does not address models that simulate the entire economy and address optimal investments in adaptation and mitigation; these are covered in the WGIII contribution to the AR5.

## **6) Multi-Sector Impacts, Risks, Vulnerabilities, and Opportunities**

The three chapters in the section on Multi-Sector Impacts, Risks, Vulnerabilities, and Opportunities revisit the sector-by-sector assessment, from a multi-sector perspective, integrating information to provide new insights. In broad terms, these chapters consider observed impacts, future impacts, and interactions among adaptation, mitigation, and development, in the context of a multi-sector analysis. This part of the assessment considers multiple sectors simultaneously, facilitating an examination of how effects combine across sectors and regions, and the consequences of this for decision-making.

Chapter 18, on “Detection and attribution of observed impacts”, uses formal and informal tools of detection and attribution analysis to synthesize observed impacts across regions and sectors. This analysis builds on the observed impacts analysis in the AR4, including literature that extracts climate signals from multi-stressor situations.

Chapter 19, on “Emergent and key risks and vulnerabilities”, explores the diverse pathways through which risks and vulnerabilities become important. One class of risks and vulnerabilities to be considered involves what were called key vulnerabilities in the AR4. These typically are important single-sector vulnerabilities, often concentrated in regions or segments of the society with low adaptive capacity. Other classes are largely new, including several types of emergent risks and vulnerabilities that become critically important only in an integrated system context. Some of these are multi-sector vulnerabilities with an importance that increases as multiple impacts of climate change converge on a single sector. For example, higher temperatures, lower precipitation, and a greater frequency of severe storms could impact agriculture in ways that are much more serious than if only one factor changed. Other emergent risks might involve settings in which vulnerability to climate change is amplified by trends in activities unrelated to climate change. Insuring food security in a setting where water availability is decreasing but anthropogenic water demands are increasing might be an example of this kind of emergent vulnerability. Another class involves risks that are transmitted, potentially over large distances, by social, cultural, and economic mechanisms. For example, an effect of climate change in one place could generate migration pressure, leading to armed conflict in another location. While all these emergent risks and vulnerabilities are difficult to quantify, their potential importance is great enough to warrant separate treatment in the AR5.

Chapter 19 also addresses the sensitivity of impacts to climate forcing, assessing the evidence for tipping points, thresholds, and other non-linearities. The chapter looks across the full diversity of mechanisms leading to impacts, risks, and vulnerabilities, and, to the extent consistent with the available evidence, identifies a group that lead to the greatest reasons for concern.

Chapter 20, on “Climate-resilient pathways: adaptation, mitigation, and sustainable development” revisits the links among adaptation, mitigation and sustainable development, emphasizing both market-based and non-market based approaches (link to WGIII). This chapter explores the utility of criteria other than cost-benefit analysis, and it looks at alternative valuation systems. It revisits the impacts of climate change on a number of sectors that are difficult to treat in monetary terms, for example biodiversity or a sense of well-being, and explores the insights that come from alternative approaches to valuation. The analysis addresses alternative approaches to comprehensively integrating impacts, adaptation, mitigation, and development, with a particular focus on pathways with the potential to provide high resilience to climate change.

## **7) Regional aspects of climate change**

The ten chapters on regional aspects of climate change provide a comprehensive summary from a regional perspective. The structure and intent of the section are based on the compromise proposal that emerged from the IPCC Plenary 30, in Antalya, Turkey, in April of 2009. Core elements of the compromise include (1) an integrated approach to regional aspects of climate, including material on the scientific basis and on adaptation (with appropriate coordination with WGI and WGIII), (2) publication of the regional section as a separate part, but sharing a single Summary for Policymakers and a single Technical Summary with the sectoral/global part of the WGII contribution, (3) coverage of all regions, including the oceans, in the regional section, and (4) appropriate treatment of subregions and case studies, with the subregions to be identified by each regional author team.

The regional section includes 10 chapters, beginning with an introductory chapter that sets the context, followed by 9 regional chapters treating (Chapter 22) Africa, (Chapter 23) Europe, (Chapter 24) Asia, (Chapter 25) Australasia, (Chapter 26) North America, (Chapter 27) Central and South America, (Chapter 28) Polar Regions, (Chapter 29) Small Islands, and (Chapter 30) International Waters.

The first chapter (Chapter 21), “Regional context” considers the kinds of information that are available at the regional level and how confidence in climate-change projections changes with spatial scale (link with WGI). It also identifies some of the ways that a regional perspective can add value, especially for regional stakeholders.

Each of the regional chapters has the same basic outline, including the *[Context]*, as discussed above. Unique features that distinguish the coverage of each sector in the regional chapters from the coverage in the sectoral chapters includes a focus on multi-sector interactions, a region-specific consideration of the role of other stressors, and a region-specific consideration of relevant information concerning the physical science basis of climate change and mitigation. Note that WGI and WGIII do not have regional chapters. Responsibility for capturing relevant material from the WGI and WGIII assessments will be handled through a combination of (1) recruiting regional authors with expertise in the WGI and WGIII subject areas and (2) maintaining close connections with the WGI and WGIII author teams, as they move through their assessments.

This part of the WGII contribution provides global coverage, including coverage of the oceans. In most regions, coastal waters are very important for regional processes, including impacts and development. For this reason, each regional chapter includes consideration of the coastal oceans and seas in that region. The chapter on international waters includes some material from Chapter 6 on “Ocean ecosystems” and incorporates material on the physical science basis and on mitigation.