CONTENTS

CLIMATE CHANGE, HUMAN SYSTEMS AND POLICY

Climate Change, Human Systems and Policy - Volume 1
No. of Pages: 408
ISBN: 978-1-905839-02-5 (eBook)
ISBN: 978-1-84826-902-6 (Print Volume)

Climate Change, Human Systems and Policy - Volume 2
No. of Pages: 376
ISBN: 978-1-905839-03-2 (eBook)
ISBN: 978-1-84826-903-3 (Print Volume)

Climate Change, Human Systems and Policy - Volume 3
No. of Pages: 393
ISBN: 978-1-905839-04-9 (eBook)
ISBN: 978-1-84826-904-0 (Print Volume)

For more information of e-book and Print Volume(s) order, please [click here](#)

Or contact: eolssunesco@gmail.com
CONTENTS

VOLUME I

Natural Resource System Challenge: Climate Change, Human Systems, and Policy
Antoaneta Yotova, National Institute of Meteorology and Hydrology, Sofia, Bulgaria

1. Introduction
   2.1. Climate changes and human history
   2.2. Anthropogenic climate influences
   2.3. Modeling of global climate change
   2.4. The Intergovernmental Panel on Climate Change (IPCC)

3. Potential large-scale effects of global warming
   3.1. Effects of global warming on rangeland and degraded lands
   3.2. Effects of global warming on wetlands
   3.3. Effects of global warming on mountains
   3.4. Effects of global warming on marine ecosystems
   3.5. Effects of global warming on water resources
   3.6. Effects of global warming on environmental pollution

4. Potential effects of global warming on human society
   4.1. Effects of global warming on human cultural diversity
   4.2. Migration as a consequence of global warming
   4.3. Implications of global warming for energy production and consumption
   4.4. Effects of global warming on agriculture
   4.5. Effects of global warming on tourism

5. Effects of potential sea-level rises
   5.1. Effects of sea-level rise on coastal cities and residential areas
   5.2. Effects of sea-level rise on coral reefs
   5.3. Effects of sea-level rise on small island states

6. Cost implications of potential climate change
   6.1. Cost implications for agriculture
   6.2. Cost implications for forestry
   6.3. Cost implications for industry
   6.4. Cost implications for fisheries
   6.5. Cost implications of storms, floods, and droughts
   6.6. Spreading the costs and benefits of measures to combat global warming

7. Response strategies for stabilization of atmospheric composition
   7.1. Energy policy and carbon dioxide emission reduction
   7.2. Energy efficiency and the switch to renewable energy resources
   7.3. Methane emission reduction and world food supply
   7.4. Nitrous oxide emission reduction and agriculture
   7.5. Chlorofluorocarbons (CFCs) and their substitutes

8. Policy framework and systems management of global climate change
   8.1. Climate change assessments
   8.2. Decision-making and policy frameworks for addressing climate change
   8.3. Climate engineering
   8.4. Abatement measures and tradable permits
   8.5. Definition and deployment of tradable permits
   8.6. Domestic and international emission tax policies
   8.7. Equity and social considerations of anthropogenic climate change
   8.8. Equity, economic discounting, and cost–benefit assessments
   8.9. Generic assessment of the costs of response strategies
   8.10. Integrated assessment of policy instruments to combat climate change
### History, Status and Prediction of Global Climate Change

Caspar Ammann, *National Center for Atmospheric Research, Climate and Global Dynamics Division, Boulder, USA*

Anne Waple, *Department of Geosciences, University of Massachusetts, USA*

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Introduction</td>
</tr>
<tr>
<td>2.</td>
<td>History of Global Climate Change Science</td>
</tr>
<tr>
<td>2.1.</td>
<td>The Early Times</td>
</tr>
<tr>
<td>2.2.</td>
<td>From the Middle Ages to the Twentieth Century</td>
</tr>
<tr>
<td>2.3.</td>
<td>Atmospheric Composition and the Greenhouse Effect</td>
</tr>
<tr>
<td>3.</td>
<td>Status of Global Climate Change</td>
</tr>
<tr>
<td>3.1.</td>
<td>A Paleoclimate Perspective</td>
</tr>
<tr>
<td>3.1.1.</td>
<td>The Twentieth Century</td>
</tr>
<tr>
<td>3.1.2.</td>
<td>The Last Millennium</td>
</tr>
<tr>
<td>3.1.3.</td>
<td>Holocene, Quaternary, and Beyond</td>
</tr>
<tr>
<td>3.2.</td>
<td>Radiative Forcing</td>
</tr>
<tr>
<td>3.2.1.</td>
<td>Attribution</td>
</tr>
<tr>
<td>3.3.</td>
<td>Status of Modeling Efforts</td>
</tr>
<tr>
<td>3.3.1.</td>
<td>From Dynamical Meteorology to Climate Modeling</td>
</tr>
<tr>
<td>3.3.2.</td>
<td>Energy Balance Models and Radiative-Convective Models</td>
</tr>
<tr>
<td>3.3.3.</td>
<td>Two-Dimensional Models</td>
</tr>
<tr>
<td>3.3.4.</td>
<td>General Circulation Models</td>
</tr>
<tr>
<td>4.</td>
<td>Prediction</td>
</tr>
<tr>
<td>4.1.</td>
<td>Rationale for Prediction Attempts</td>
</tr>
<tr>
<td>4.2.</td>
<td>Forcing</td>
</tr>
<tr>
<td>4.2.1.</td>
<td>Greenhouse Gases</td>
</tr>
<tr>
<td>4.2.2.</td>
<td>Anthropogenic Aerosols</td>
</tr>
<tr>
<td>4.2.3.</td>
<td>Solar Variability</td>
</tr>
<tr>
<td>4.2.4.</td>
<td>Volcanic Eruptions</td>
</tr>
<tr>
<td>4.3.</td>
<td>Variability</td>
</tr>
<tr>
<td>4.3.1.</td>
<td>Intermonthly–Interannual</td>
</tr>
<tr>
<td>4.3.2.</td>
<td>Decadal–Centennial</td>
</tr>
<tr>
<td>4.3.3.</td>
<td>Extreme Events</td>
</tr>
<tr>
<td>4.4.</td>
<td>Feedbacks</td>
</tr>
<tr>
<td>4.4.1.</td>
<td>Clouds</td>
</tr>
<tr>
<td>4.4.2.</td>
<td>Vegetation</td>
</tr>
<tr>
<td>4.4.3.</td>
<td>Snow and Ice</td>
</tr>
<tr>
<td>4.5.</td>
<td>Mean Climate Response</td>
</tr>
<tr>
<td>4.5.1.</td>
<td>Spatial Patterns</td>
</tr>
<tr>
<td>5.</td>
<td>Policy Implications</td>
</tr>
</tbody>
</table>

### Climate Changes and Their Influence on Human History

György Koppány, *University of Szeged, Hungary*

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Introduction</td>
</tr>
<tr>
<td>2.</td>
<td>Climate Changes in Prehistorical Times and Before Recent Age</td>
</tr>
<tr>
<td>3.</td>
<td>Climate Variation and the Second World War</td>
</tr>
<tr>
<td>4.</td>
<td>The Largest Population Density on Earth and the Climate</td>
</tr>
<tr>
<td>5.</td>
<td>Carbon Cycle in the Earth-Atmosphere System and the Climate</td>
</tr>
</tbody>
</table>

### Anthropogenic Climate Influences

Boroneant Constanta E., *National Institute of Meteorology and Hydrology, Bucharest, Romania*

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Introduction</td>
</tr>
<tr>
<td>2.</td>
<td>The Climate and Climate System</td>
</tr>
<tr>
<td>2.1.</td>
<td>The Driving Forces of Climate</td>
</tr>
</tbody>
</table>
2.2. The Greenhouse Effect

   3.1. Carbon Dioxide (CO₂)
   3.2. Methane (CH₄)
   3.3. Nitrous Oxide (N₂O)
   3.4. Halocarbons
   3.5. Ozone (O₃)
      3.5.1. Stratospheric Ozone
      3.5.2. Tropospheric Ozone
   3.6. Atmospheric Aerosols
      3.6.1. Natural Aerosols
      3.6.2. Anthropogenic Aerosols

4. Anthropogenic Influence on Land
   4.1. Deforestation
   4.2. Desertification
   4.3. Urbanization

5. Conclusions

The Intergovernmental Panel on Climate Change (IPCC)
Bert Bolin, Professor Emeritus, Former Chairman of the IPCC, Sweden

1. The Formation of the Intergovernmental Panel on Climate Change and Its Task
2. The Historical Background
3. The First IPCC Assessment Gets Under Way
4. Scientific Input to the Negotiations about a Framework Convention
5. Reorganization of the IPCC
6. The Second Assessment Report
7. Heading for a Third Assessment
8. Lessons to Be Learned

Effects of Global Warming on Wetlands
J.O. Ayoade, Department of Geography, University of Ibadan, Nigeria

1. Introduction
2. Global Warming
3. Wetlands
4. Effects of Global Warming on Wetlands

The Effects of Global Warming on Mountains
Martin Beniston, University of Fribourg, Switzerland

1. Introduction
2. Impacts of Global Warming on Natural Systems in Mountains
   2.1. Impacts on Hydrology
   2.2. Impacts on Mountain Cryosphere
   2.3. Impacts on Ecological Systems
3. Impacts on Socioeconomic Systems
   3.1. Mountain Agriculture
   3.2. Tourism
   3.3. Hydropower and Other Commercial Activities
4. Policy Response

Effects of Global Warming on Forests
Ian D. Campbell, Fire Research and Criteria and Indicators of Sustainable Forest Management,
1. Introduction
2. Controls on Forest Distribution
   2.1. Major Direct Climatic Controls
   2.2. Air Masses and Tree Lines
   2.3. Other Direct Climatic Controls
   2.4. Climate Feedbacks
   2.5. Indirect Climate Controls
3. Impacts of Past Climate Changes
   3.1. Postglacial Migration
   3.2. Hypsithermal Distribution
   3.3. Periods of Rapid Change
4. Projected Trends
   4.1. Changes in Distribution
   4.2. Other Changes in Environmental Conditions
   4.3. Changes in Environmental Services
      4.3.1. Hydrological Cycle
      4.3.2. Carbon Cycle
5. Possible Early Warnings
6. Policy Challenges
7. Conclusions

Effects of Global Warming on Marine Ecosystems
Gennady G. Matishov, Murmansk Marine Biological Institute, Russia

1. Introduction
2. The Ocean and Global Climatic Trends
3. Marine Ecosystems
4. Marine Organisms
5. Hydrological Fronts and Ice Cover
6. Evolution of Ocean Ecosystems
7. Marine Environment and Biological Resources
8. Conclusion

Effects of Global Warming on Water Resources and Supplies
Bela Novaky, Szent István University, Gödöllő, Hungary

1. Introduction
2. Climate and Hydrological Cycle
3. Climate Change and Hydrological Cycle
   3.1. Methodological Questions of Climate Change Impact Assessment
   3.2. Results of Climate Change Impact Assessment
4. Conclusions

Effects of Global Warming on Environmental Pollution: An Area with many Knowledge Gaps
Bo L. B. Wiman, Natural Resources Management Research Unit, Department of Biology & Environmental Science, Kalmar University, Sweden

1. Introductory Observations
2. The Problem of Indirect and Direct Effects
3. Climate-change Interactions With Biogeochemical Cycling
4. A Few Examples
5. Concluding Remarks

Global Warming, Poverty, and Ethical Issues
Joanne Bauer, Director of Studies, Carnegie Council on Ethics and International Affairs, New York, USA

1. Who Bears the Burden of Global Warming?
   1.1. Facts
   1.2. Impacts on Rich Countries
   1.3. The Ethics of Climate Forecast Dissemination
   1.4. Intergenerational Equity
2. The Moral Imperative to Act
3. Justice in International Politics
   3.1. The Role of Justice in "Climate change" Negotiations
   3.2. What Activists Want: Justice as Viewed from "on the Ground"

Effects of Global Warming on Human Cultural Diversity
Marie D. Hoff, Catholic Charities of Idaho, Boise, Idaho, USA

1. Introduction
2. Global Warming, Agriculture, and Cultural Diversity
   2.1. Threats to Agriculture
      2.1.1. Changes in Weather and Water Supplies
      2.1.2. Direct Effects of Climate and Weather on Crops and Animals
      2.1.3. Effects of Agricultural Change on Vulnerable Human Populations
3. Environmental Refugees
4. The Cultural Impacts of Human Disease Associated with Global Warming
   4.1. Increases in Infectious Diseases
   4.2. Effects on Mental Health of Individuals
   4.3. Effects on Intellectual Resources of Cultural Groups and Societies
   4.4. Disruption of Family Life Inhibits Transmission of Culture
5. Effects of Climate Change on Indigenous Peoples and Island Cultures
   5.1. Forests and Indigenous Peoples as Resources to Mitigate Climate Change
   5.2. Small Island Cultures and Societies
   5.3. Loss of Diverse Cultures Impoverishes All Humanity
6. Relationships between Global Warming and Social Violence
   6.1. Local Environments Destroyed by Military Activity
   6.2. Direct and Indirect Effects of Military Spending on Social Development
      6.2.1. Disadvantaged Populations Most Vulnerable to Violence
7. Policy and Research Priorities, with Intervention Principles
   7.1. Policy and Research Priorities Regarding Energy and Transportation
   7.2. Policy and Research Priorities for Population Control and Women’s Development
   7.3. Assistance to the World’s Most Vulnerable Cultural and Population Groups
   7.4. Organic Agricultural Development to Maintain Cultural Diversity
   7.5. Intervention Principles and Values
      7.5.1. Utilize Practical Knowledge Gained from Social Sciences
      7.5.2. Procedural Justice
      7.5.3. Substantive Justice
8. Conclusion

Global Warming and Human Migration
Hermen J. Ketel, KETEL s.a.r.l. Sustainable Development Advice, France

1. Introduction
2. The Problem and the State of the Art
3. Preventive Action
4. Mitigation
5. Rehabilitation
6. Policy Guidelines and Roles of Different Actors
7. Conclusion

The Implications of Global Warming for Energy Production and Consumption 280
Karina Garbesi, California State University, Hayward, USA

1. Introduction
2. Energy Options for Carbon Abatement
   2.1. The Role of Energy Efficiency
   2.2. The Trade-offs of Nuclear Power
       2.2.1. Security Risks of a Breeder Reactor Economy
       2.2.2. Other Problems Inherent in Nuclear Power
   2.3. Substituting Natural Gas for Coal and Oil
   2.4. Carbon Sequestration
   2.5. Renewable Energy Sources
3. Transportation
4. Sustainable Cities: An Integrated Approach
5. Conclusions

Climate Change and Agriculture 309
Richard M. Adams, Department of Agricultural and Resources Economics, Oregon State University, USA

1. Introduction
2. Agriculture and Climate
   2.1. The Biophysical Dimensions
       2.1.1. Temperature
       2.1.2. Rainfall
       2.1.3. Carbon Dioxide Concentrations
       2.1.4. Climate Variability and Extreme Events
       2.1.5. Indirect Effects
   2.2. The Dimensions of Human Response
3. Climate Change Impacts on Crop Yields and Livestock Performance
   3.1. Crop Yield Responses to Climate Change
   3.2. Livestock Performance Responses to Climate Change
4. Role of Human Response and Adaptation to Climate Change
   4.1. Adaptation and Adjustment of Agricultural Systems to Climate Change
   4.2. Economic Approaches to Measuring Climate Change Effects
   4.3. The Structural Approach
   4.4. The Spatial Analogue Approach
   4.5. Importance of Adaptation Assumptions in Economic Assessments
5. Impacts of Climate Change on Agricultural Production, Prices, and Welfare
   5.1. Estimated Crop Supply and Price Response
   5.2. Potential Impacts on Economic Welfare
6. Environmental Effects on Agricultural Production
7. Mitigation of Greenhouse-Gas Emissions
   7.1. Mitigating Agricultural Emissions
   7.2. Sequestering Carbon
8. Conclusions

Effects of Global Warming on Tourism 328
Tanja Cegnar, Hydrometeorological Institute of Slovenia, Slovenia
1. Introduction
2. Tourism in the Future
3. Climate and Its Components
   3.1. Solar Radiation
   3.2. Temperature
   3.3. Severe Weather and Weather Extremes
4. Climate and Weather Impacts on Humans
5. Winter and Summer Tourism
6. Mountains
7. Health Resorts
8. City Tourism
9. Seasonal Migrations
10. Conclusions

Index

About EOLSS

VOLUME II

Effects of Sea-Level Rise on Coastal Cities and Residential Areas
Roland P. Paskoff, Lumière University, Lyon, France

1. Introduction
2. Impacts of Sea-level Rise on Coastal Urbanized Area
   2.1. Intensified Flooding
   2.2. Increased Erosion
   2.3. Salt-water Intrusion
   2.4. Impeded Drainage
3. Urban Planning for Sea-level Rise
   3.1. Inaction
   3.2. Accommodation
   3.3. Evacuation
   3.4. Protection
      3.4.1. Hard Protection
      3.4.2. Soft Protection
   3.5. Counterattack
   3.6. Anticipatory Actions
4. Conclusion

Effects of Sea-Level Rise on Coral Reefs
S. Peevor, Department of Geographical and Environmental Studies, University of Adelaide, Australia
Jan E. Carey, UNEP–University of Adelaide International Graduate Program in Environmental Management, University of Adelaide, Australia

1. Introduction
2. Coral Reefs in Earth’s History
3. Coral Ecology and Reef-Building Processes
   3.1. Coral Reef Distribution
   3.2. Coral Reef Morphology
   3.3. Coral Ecology
      3.3.1. Reef-Building Corals
      3.3.2. Reef-Forming Processes
3.3.3. Sea-Level Dynamics and Reef-Forming Factors

3.4. Factors Affecting Responses by Corals to Sea-Level Rise

3.4.1. Location in the Photic Zone
3.4.2. Availability of Suitable Substrate
3.4.3. Effect of Sea-Level Rise on Coral Growth Rates
3.4.4. Changes in Wave Action and Sediment Transport
3.4.5. Bioerosion
3.4.6. Nutrient Delivery and Recycling
3.4.7. Direct Effects of Change in Global Atmospheric Circulation
3.4.8. Temperature

3.5. Impact of Sea-Level Rise in Combination with Factors Affecting Coral Growth

4. Sea-Level Rise and Human Activities

4.1. Potential Impacts of Sea-Level Rise on Coastal Communities
4.2. Impacts of Coastal Communities on Coral Reefs

5. Future Management and Research Needs of Coral Reefs

6. Conclusions

---

**Effects of Sea-Level Rise on Small Island States**

Sachooda Ragoonaden, *Mauritius Meteorological Services, Mauritius*

1. Introduction
2. Regional Climate
   2.1. Past and Future Climate
      2.1.1. Temperature
      2.1.2. Rainfall
      2.1.3. Tropical Cyclones
      2.1.4. Other Weather Systems
      2.1.5. Sea Level—Past and Future
3. Coastal Sensitivity to Sea-Level Rise
   3.1. Coral Reefs
   3.2. Mangroves
   3.3. Beaches and Coastal Changes
   3.4. Coastal Tourism
   3.5. Infrastructure and Settlement
4. Assessment of the Vulnerability of Small Island States to Sea-Level Rise
   4.1. IPCC Common Methodology
5. Adaptation Options
   5.1. Adaptation Strategies
   5.2. Coastal Protection Methods
      5.2.1. Rubble-Mound Structures
      5.2.2. Revetment
      5.2.3. Breakwaters
      5.2.4. Groins
      5.2.5. Gabions
      5.2.6. Sandbag and Filter-Cloth Bag Structures
      5.2.7. Vertical Walls and Bulkheads
      5.2.8. Beach Nourishment
6. Implementation Considerations and Constraints
   6.1. Integrated Coastal Zone Management
7. Conclusions

---

**Economics of Potential Climate Change**

Ekkko C. van Ierland, *Wageningen University and Research Centre, The Netherlands*
Marcel G. Klaassen, *Wageningen University and Research Centre, The Netherlands*
Judit A. Szonyi, *Wageningen University and Research Centre, The Netherlands*
1. Introduction
2. Damage Cost Implications for Sectors
   2.1. Agriculture
   2.2. Forestry
   2.3. Fisheries
   2.4. Industry
   2.5. Water Supply
   2.6. Energy Production
3. Damage Costs of Socioeconomic Impacts
   3.1. Human Health
   3.2. Natural Disasters
   3.3. Sea-Level Rise
4. Spreading the Costs and Benefits of Global Warming

**Economic Implications of Climate Change for Agriculture**
W. Neil Adger, *School of Environmental Sciences and CSERGE, University of Anglia, U.K.*

1. Economics of Climate-Change Mitigation in Agriculture
   1.1. Land-Use Mitigation Options
   1.2. The Interaction of Agriculture and Mitigation through Afforestation
   1.3. Climate-Change Mitigation from Rice and Livestock Production
   1.4. Summary of Economic Impacts of Mitigation on Agriculture
2. The Costs of Climate-Change Impacts

**Cost Implications of Climate Change for Forestry**
Birger Solberg, *Department of Forest Sciences, Agricultural University of Norway*

1. Introduction
2. Study Overviews
   2.1. Physical and Environmental Impacts
   2.2. Cost Implications
      2.2.1. Costs Related to Industrial Roundwood and Forest Industry Products
      2.2.2. Costs Related to Non-Marketed Goods and Services from Forestry
3. Future Priorities Regarding Cost Analyses
4. Conclusions

**The Cost Implications (of Potential Global Climate Change) for Industry**
Paul Ekins, *The Environment Group at the policy Studies Institute, UK*

1. Introduction
2. The Costs to Industry of Damage from and Adaptation to Climate Change
3. The Costs to Industry of Attempts to Mitigate Climate Change
   3.1. The Costs of Climate Change Mitigation for a Single Firm
   3.2. The Costs of Climate Change Mitigation for Industrial Sectors
   3.3. The Costs of Climate Change Mitigation for the National Economy
4. Conclusion

**Cost Implications for Fisheries**
Brian J. Shuter, *Ontario Ministry of Natural Resources/University of Toronto, Canada*
Charles Kenneth Minns, *Department of Fisheries and Oceans, Burlington, Canada*

1. Introduction
2. Impacts of Climate Change on Fish
   2.1. Changes in Fish Production in a Particular Locale
2.1.1. Productivity of Entire Fish Communities
2.1.2. Productivity of Individual Fish Populations within a Community
2.2. Changes in Fish Spatial Distributions
   2.2.1. Long-Term Changes in the Distribution Boundaries of Species
   2.2.2. Short-Term Variation in the Distribution of Population Members
3. Direct Impacts on Fisheries
4. Indirect Impacts of Fish and Fisheries
5. Valuing Fisheries
6. Managing the Costs of Climate Change
   6.1. Regional Adaptation Tactics
   6.2. National Adaptation Strategy

**Cost Implications of Storms, Floods, and Droughts**

Alexander A. Olsthoorn, *Institute of Environmental Studies, Vrije University, The Netherlands*

Richard S.J. Tol, *Centre for Marine and Climate Research, Hamburg University; Institute for Environmental Studies, Vrije Universiteit, Amsterdam; Center for Integrated Study of The Human Dimensions of Global Change, Carnegie Mellon University, Pittsburgh*

1. Introduction
2. Windstorms
   2.1. Extratropical Storms
   2.2. Tropical Storms
3. River Floods
4. Droughts
5. Insurance
6. Disaster Relief
7. Conclusion

**Sharing the Costs of Climate Change**

Christiaan Vrolijk, *The Royal Institute of International Affairs, UK*

Michael Grubb, *Imperial College of Science, Technology and Medicine, UK*

1. Introduction—the Costs of Climate Change
2. Sharing the Burden
   2.1. The UN Framework Convention on Climate Change
   2.2. The Kyoto Protocol
   2.3. The EU Burden Sharing Agreement
3. Flexibility Reduces Costs
   3.1. Negotiating History
   3.2. Flexibility in the Kyoto Protocol
4. Fairness in Future Climate Change Negotiations
5. Conclusions

**Response Strategies for Stabilization of Atmospheric Composition**

R. Alexander Roehrl, *International Institute for Applied Systems Analysis (IIASA), Austria*

1. Introduction
2. Greenhouse-Gas Emissions Drivers and Baseline Scenarios
   2.1. Energy-Related Carbon Dioxide Emissions and the Kaya Identity
   2.2. Scenario Driving Forces
      2.2.1. Population
      2.2.2. Economic Development
      2.2.3. Energy Technologies and Fossil Energy Resources
      2.2.4. Land Use
3. Limiting Greenhouse Gases: Emissions Drivers and Emissions Reduction
3.1. Energy Sector
   3.1.1. Energy-Related Emissions Sources
   3.1.2. Reduction Measures for Energy-Related Greenhouse-Gas Emissions
3.2. Halocarbons and Other Non-Energy Industrial Emissions
3.3. Agriculture and Land-Use Emissions
   3.3.1. Sources and Emissions Drivers
   3.3.2. Reduction Measures of Land-Use Related Emissions
3.4. Current Atmospheric Concentrations of the Main Greenhouse Gases
3.5. Implementing Greenhouse-Gas Reduction Measures

4. Greenhouse-Gas Mitigation Scenarios and Costs to Achieve Stabilization of Atmospheric Composition
   4.1. Atmospheric Greenhouse-Gas Stabilization Scenarios
   4.2. Costs

5. International Policy Framework and Collaboration to Combat Climate Change
   5.1. United Nations Framework Convention on Climate Change and Kyoto Protocol
   5.2. Financing Action under the Climate Change Convention and Global Cooperation on Technology

---

**Energy Policies for Carbon Dioxide Emission Reduction**
Valentina Dinica, *University of Twente, The Netherlands*

1. Introduction
2. Sources of Carbon Dioxide Emissions and Focus of Energy Policies
3. The Challenge Facing Energy Policies
   4.1. Classification of Measures
   4.2. Supply-Side Measures—Production of Electricity and Heat
   4.3. Supply-Side Measures—Non-Electric Transport
   4.4. Demand-Side Measures—Energy Consumption by Industrial Activities
   4.5. Demand-Side Measures—Energy Consumption in the Residential/Commercial Sector
   4.6. Demand-Side Measures—Energy Consumption in the Non-Electric Transport Sector
   4.7. Summary of Technical and Non-Technical Measures for Carbon Dioxide Emission Reduction
   5.1. National Policy Instruments and Categories of Measures They Can Facilitate
      5.1.1. Projects Supported by Public Authorities
      5.1.2. Direct Regulations
      5.1.3. Economic Instruments
      5.1.4. Information and Communication Policy Instruments
      5.1.5. Voluntary Agreements
   5.2. Combinations, Advantages, and Disadvantages of Policy Instruments
6. International Cooperation Mechanisms
   6.1. Joint Implementation
   6.2. Clean Development Mechanism
   6.3. International Emissions Trade
   6.4. Combinations, Advantages, and Disadvantages of International Cooperation Mechanisms
7. Conclusion: Energy Policies for Climate Change Abatement

---

**Energy Savings Through Changes in Lifestyles and Economics**
Jorgen S. Norgård, *Technical University of Denmark, Denmark*

1. Introduction
2. Energy System Models and Concepts
   2.1. Energy Chain Model
   2.2. Technological Links in the Energy Chain
   2.3. The Soft End of the Energy Chain
2.4. Means and Ends in Energy Systems

3. The Effect of Energy Savings on Lifestyles and Economics
   3.1. Preindustrial Economic Development
   3.2. Growth, Development, and Satiation Today
   3.3. Derived Needs and Consumption
   3.4. Lifetime of Durable Goods
   3.5. Efficiency through Sharing
   3.6. Sustainable and Efficient Welfare Economy

4. End-Use Efficiency Savings
   4.1. Historical End-Use Efficiency
   4.2. Further Options for End-Use Efficiency Improvements
   4.3. Cost of End-Use Efficiency Savings
   4.4. Cooking
   4.5. Space Heating
   4.6. Space Cooling
   4.7. Transportation of Goods and People
   4.8. Electrical Appliances
   4.9. Industrial Processes
   4.10. Conclusions about End-Use Efficiency Options

5. Renewable Energy Supply Options
   5.1. Comparing Renewable and Nonrenewable Energy
   5.2. Biomass for Energy
   5.3. Hydropower
   5.4. Direct Solar Energy
   5.5. Other Renewable Energy Resources

6. Overall System Integration
   6.2. Fluctuations and Storage Needs
   6.3. Optimizing versus Suboptimizing
   6.4. Pitfalls of End-Use Efficiency
   6.5. Market Economy and Efficiencies

7. Concluding Remarks

Methane Emission Reduction and World Food Supply  265
M. V. K. Sivakumar, World Meteorological Organization, Switzerland

1. Introduction
2. Effects of Methane Accumulation in the Atmosphere
3. Factors Contributing to Methane Accumulation in the Atmosphere
   3.1. Natural Sources (Wetlands, Oceans, and Lakes)
   3.2. Flooded Rice
   3.3. Ruminants
   3.4. Biomass Burning
   3.5. Landfill
   3.6. Methane Oxidation in Soil
4. Mitigation of Methane Accumulation in the Atmosphere
   4.1. Flooded Rice
   4.2. Ruminants
   4.3. Biomass Burning
   4.4. Landfill
5. Food Security Issues Affecting the Agriculture, Forestry and Waste Management Sectors
6. Uncertainties and Future Research Needs

Nitrous Oxide Emission Reduction and Agriculture  278
Arvin R. Mosier, USDA/ARS, USA
John Raymond Freney, CSIRO Plant Industry, Australia
1. Introduction
2. Emission of Nitrous Oxide from Agricultural Lands
   2.1. Direct Emissions of Nitrous Oxide
   2.2. Emission of Nitrous Oxide from Animal Production Systems
   2.3. Indirect Emissions of Nitrous Oxide from Nitrogen used in Agriculture
   2.4. Biomass Burning
3. Food Production and Fertilizer Consumption
4. Fertilizer Consumption and Nitrous Oxide Production
5. Fertilizer Nitrogen Use Projections and Nitrous Oxide Emissions
6. Mitigation of Nitrous Oxide Emissions from Intensive Crop Production Systems
   6.1. Match Nitrogen Supply with Crop Demand
      6.1.1. Soil and Plant Testing
      6.1.2. Minimize Fallow Periods
      6.1.3. Optimize Split Applications
      6.1.4. Reduce Production Goals
   6.2. Tighten Nitrogen Flow Cycles
      6.2.1. Integrate Animal and Crop Production
      6.2.2. Conserve Residues
   6.3. Use Advanced Fertilization Techniques
      6.3.1. Controlled Release Fertilizers
      6.3.2. Fertilizer Placement
      6.3.3. Foliar Application
      6.3.4. Use of Inhibitors
      6.3.5. Timing and Matching Fertilizer Type to Precipitation
   6.4. Optimize Tillage, Irrigation, and Drainage
7. Effects of Mitigation Techniques on Nitrous Oxide Emission
3.1. Intergenerational solidarity and timely action
3.2. The precautionary principle
3.3. The common but differentiated responsibility
3.4. Efficiency
4. Historical perspective on climate negotiations
  4.1. Before Rio: a quick start, then a failed EU initiative
  4.2. From Rio 1992 to Berlin: the diplomatic timing and the adoption of binding targets
  4.3. Tentative assessment of Kyoto quantitative targets
5. Concluding remarks

Climate Change Assessments
Anne Mette K. Joergensen, Danish Meteorological Institute, Denmark

1. Introduction
3. The IPCC Second Assessment Report, 1995
    3.1.1. Greenhouse Gas Concentrations
    3.1.2. Anthropogenic Aerosols
    3.1.3. Climate Change over the Twentieth Century
    3.1.4. A Discernible Human Influence on Global Climate
    3.1.5. Future Climate Change
    3.1.6. Uncertainties
    3.2.1. Energy
    3.2.2. Agriculture, Rangelands, and Forestry
    3.2.3. Policy Instruments
  3.3. The Working Group III Report—Economic and Social Dimensions of Climate
    3.3.1. Decision Making
    3.3.2. Equity and Social Considerations
    3.3.3. Intertemporal Equity and Discounting
    3.3.4. Applicability of Cost and Benefit Assessments
    3.3.5. The Social Costs of Anthropogenic Climate Change: Damages of Increased Greenhouse Gas Emissions
    3.3.6. Generic Assessment of Response Strategies
    3.3.7. Costs of Response Options
    3.3.8. Integrated Assessment
    3.3.9. An Economic Assessment of Policy Instruments to Combat Climate Change
4. The Third Assessment Report

Decision Making and Policy Frameworks for Addressing Climate Change
Peter L. Read, Massey University, New Zealand

1. Introduction
2. The Dimensions of the Climate Change Issue
   2.1. Pollution
   2.2. Global
   2.3. Stock
   2.4. Pervasive Uncertainty
   2.5. Very Long Term
   2.6. Summary
3. The Climate Change Decision Process
   3.1. Filtered Information
3.2. Special Interests and the Operation of the Framework Convention on Climate Change
3.3. Advances with Decision Process Research
   3.3.1. Partial Coalition Agreements
   3.3.2. Implementation, Compliance, and Verification
3.4. Summary of the Decision Process
4. Decision Analysis in Climate Change
   4.1. Decision Analysis Methods
      4.1.1. Basic Cost-Benefit Analysis
      4.1.2. Enhanced Cost-Benefit Analysis
      4.1.3. Cost-Effectiveness Analysis
      4.1.4. Multi-Criteria Analysis
      4.1.5. Regret Analysis
      4.1.6. Tolerable Windows Approach
      4.1.7. Exploratory Modeling and Robust Strategies
   4.2. Stock Pollution Dynamics
      4.2.1. The Response Timing Debate
      4.2.2. Competing Technologies and Increasing Returns
      4.2.3. Dynamic Policy Efficiency
5. Review: Synergies and Prospects

Climate Engineering: Concepts, Examples, and Risks 76
Bo L. B. Wiman, Kalmar University, Sweden
1. Introductory Examples and Concepts
2. Concerns About Climate Change
3. Categories of Responses to Climate Change Risks
4. Basic Ideas of Geo-engineering
5. Responses to the Geo-engineering Option
6. Concluding Remarks

Carbon Dioxide Mitigation and Adaptation Options 89
Christian Azar, University of Göteborg, Sweden
1. Introduction
2. Mitigation Options
   2.1. Reducing Energy Use
      2.1.1. Population
      2.1.2. Income Per Capita and Prevailing Lifestyles
      2.1.3. Energy Efficiency
      2.1.4. Reducing Energy Use—Some Concluding Observations
   2.2. Options to Reduce Carbon Emissions from Energy Supply
      2.2.1. Intra-Fossil Fuel Substitution
      2.2.2. Fossil Fuel Decarbonization or Carbon Sequestration of the Stack Gases
      2.2.3. Nuclear Energy
      2.2.4. Renewable Energy
   2.3. Conclusions
3. Adaptation

ZhongXiang Zhang, Research Program, East-West Center, Honolulu, USA; Centre for Environment and Development, Chinese Academy of Social Sciences, Beijing; China Centre for Regional Economic Research, Peking University, Beijing, PRC
1. Introduction
2. Emissions Trading Models
   2.1. Intergovernmental Emissions Trading Versus Inter-Source Trading
2.2. The Structure of National Emissions Trading Systems

3. The Initial Allocation of Permits and Competitiveness Concerns
   3.1. The Initial Allocation of Permits: Grandfathering Versus Auctioning
   3.2. Competitiveness Concerns in the Allocation of Permits
   3.3. Harmonizing Allocation of Permits?

4. Banking and Borrowing

5. The Liability Rules for Non-Compliance
   5.1. Seller-Beware Liability
      5.1.1. Eligibility to Participate in Emissions Trading
      5.1.2. An Escrow Account
      5.1.3. A Compliance Reserve
      5.1.4. Annual Retirement
      5.1.5. Compulsory Insurance
   5.2. Buyer-Beware Liability

6. Bubbles

7. Conclusion

Definition, Development, and Deployment of Tradable Permits 130
Benito Müller, Oxford Institute for Energy Studies, UK

1. The "Production" of Permits: Allowance Trading and Credit Trading
2. The "Consumption" of Permits
3. Environmental Integrity and Allocative Equity
   3.1. Environmental Caps and Trading Allocations
   3.2. Flexibilities in Implementation and Environmental Integrity
   3.3. Credit Baselines for Unconstrained Sources
   3.4. Trading Allocations and Allocative Equity
4. Fostering Environmental Integrity: The Administrative System
   4.1. Monitoring and Reporting
   4.2. Certification
   4.3. Compliance
5. Fostering Economic Efficiency: The Market Institutions

What Do We Know About Carbon Taxes? An Inquiry Into Their Impacts On Competitiveness And Distribution Of Income 147
Zhong Xiang Zhang, Faculty of Law and Faculty of Economics, University of Groningen, the Netherlands

1. Introduction
2. Energy taxes versus carbon taxes
3. The treatment of the carbon tax revenues
4. Distributive implications
5. International competitiveness
6. Conclusions

Equity and Social Considerations of Anthropogenic Climate Change 167
Lasse Ringius, UNEP Collaborating Center on Energy and Environment, Denmark

1. Introduction
2. Equity Principles and Burden Sharing Rules
3. Equity in the FCCC and the Kyoto Protocol
4. Proposals for Burden Sharing and Differentiation
   4.1. Proposals by Analysts
   4.2. Proposals by Governments
5. Towards A Framework for Equity and Differentiation among Countries
6. Conclusions
CLIMATE CHANGE, HUMAN SYSTEMS AND POLICY

Discounting, Equity, and Cost-Benefit Analysis 181
Hans Asbjorn Aaheim, University of Oslo, Norway

1. The Impact of Alternative Choices of a Discount Rate
2. The Determinants of the Discount Factor
3. The Social Return on Capital
4. The Intertemporal Welfare Function
5. Long-Term Aspects and Sustainability
6. Concluding Remarks

Generic Assessment of the Costs of Response Strategies 198
Kirsten Halsnaes, UNEP, Denmark

1. Introduction
2. Definition of Key Concepts
3. Decision-Making Framework
   3.1. Climate Change Damage Estimates
4. Adaptation and Mitigation Costs and the Linkages between Them
5. Basic Issues Related to Climate Change Cost Concepts
   5.1. Social and Financial Costs
   5.2. External Cost, Private Cost, and Social Cost
      5.2.1. Social Cost = External Cost + Private Cost
   5.3. Cost Analysis and Development, Equity and Sustainability Aspects
   5.4. Implementation Costs and Barrier Removal
6. Main Issues in Adaptation Cost Assessment
7. Main Issues in Mitigation Cost Assessment
   7.1. Categorization of Climate Change Mitigation Options
   7.2. Analytical Approaches—Top-Down and Bottom-Up Models
   7.3. Critical Assumptions in Climate Change Mitigation Studies
8. Mitigation Cost Estimates

Integrated Assessment of Policy Instruments to Combat Climate Change 214
Hans Asbjorn Aaheim, University of Oslo, Norway

1. Introduction
2. The Modules of Integrated Assessment Models
   2.1. Atmospheric Effects
      2.1.1. The Representation of Greenhouse Gases
      2.1.2. Sinks and the Carbon Cycle
   2.2. The Impacts of Climate Change
3. Damage Assessments
   3.1. Damage Estimates
   3.2. Damage Functions
4. Valuation of Non-Marketable Impacts
5. Uncertainty

The Climate System 235
A. Henderson-Sellers, Director Environment, Australian Nuclear Science and Technology Organization, Sydney

1. Earth’s Climate
   1.1. Introduction
   1.2. Earth as a Planet
   1.3. Forcing and Feedbacks
      1.3.1. Snow and Ice: A Surface Feedback
1.3.2. Water Vapor: An Atmospheric Feedback
1.3.3. Biogenic Feedbacks in the Climate System
1.3.4. Combining Climate System Feedbacks

2. Past Climates
2.1. Spectrum of Past Variability
2.2. Solar Variations
   2.2.1. Milankovitch
   2.2.2. Sunspots and Shorter Period Solar Irradiance Changes
2.3. Climate of the mid-Holocene (6000 yr BP)
2.4. The Last Glacial Maximum (21 000 yr BP)

3. Climate Models
3.1. Models as Tools
3.2. Climate Model Hierarchy
3.3. Global Climate Models (GCMs)
3.4. Earth System Models of Intermediate Complexity (EMICs)
3.5. Simulating Interactions in the Climate System

4. Human Impact on Climate
4.1. Stratospheric Ozone Depletion
4.2. Global Warming
4.3. Land-surface Forcing and Its Effects

5. Sustaining Climate

Global Climate And Human Activities

Sir John Houghton, Scientific Assessment Working Group Of The Intergovernmental Panel On Climate Change, Hadley Centre For Climate Prediction And Research, Bracknell, Uk

1. The Science of Climate Change
   1.1. The Variability of Climate
   1.2. The Greenhouse Effect
   1.3. The Intergovernmental Panel on Climate Change (IPCC)
   1.4. Greenhouse Gases
   1.5. Other Factors Influencing Climate Change
   1.6. Has Anthropogenic Climate Change been Observed?
   1.7. The Modeling of Climate Change
   1.8. Future Anthropogenic Climate Change

2. The Impacts of Climate Change
   2.1. Sea Level Rise
   2.2. Impact on Water Availability
   2.3. Impacts on Food and Health
   2.4. Costing the Impact of Climate Change

3. The Framework Convention on Climate Change (FCCC)
   3.1. The Establishment of the FCCC
   3.2. The Kyoto Protocol

4. The Mitigation of Climate Change
   4.1. Actions to Mitigate Climate Change
   4.2. Forestry
   4.3. Methane Reduction
   4.4. Sequestration of Carbon Dioxide
   4.5. Energy Generation and Use
   4.6. Contraction and Convergence
   4.7. The Achievement of Change and the Likely Cost

Climate Change And Natural Resources Policy And Management

G.O.P. Obasi, Secretary-General, World Meteorological Organization, Geneva
1. Introduction
2. Climate change, climate variability and the greenhouse effect
3. Observed climate variability and change
   3.1. Long time-scale climate variability and changes
   3.2. Anthropogenic influences
4. Future climate projections
   4.1. Climate models
   4.2. Factors affecting the magnitude and rate of future changes
   4.3. IPCC climate scenarios
   4.4. Projections of temperature and sea-level rise
   4.5. Regional distribution of changes
5. Climate change — natural resources linkage
   5.1. Fresh water
   5.2. Forestry
   5.3. Other terrestrial ecosystems
   5.4. Aquatic ecosystems
   5.5. Human health
   5.6. Carbon fuel
6. Climate change and natural resources policy and management
   6.1. Observation and monitoring of climate
   6.2. Climate research
   6.3. Prediction and early warning
   6.4. Capacity building
   6.5. Protection of the environment
   6.6. International and regional cooperation
   6.7. Disaster preparedness and natural resources management policies
   6.8. Education and awareness

Index

About EOLSS