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Intergovernmental Panel on Climate Change

The **Intergovernmental Panel on Climate Change (IPCC)** is an intergovernmental body of the United Nations responsible for advancing knowledge on human-induced climate change.^{[1][2][3][4]} It was established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Programme (UNEP), and later endorsed by United Nations General Assembly.^[5] Headquartered in Geneva, Switzerland, it is composed of 195 member states.^{[6][7]}

The IPCC provides objective and comprehensive scientific information on anthropogenic climate change, including the natural, political, and economic impacts and risks, and possible response options. It does not conduct original research nor monitor climate change, but rather undertakes a periodic, systematic review of all relevant published literature.^{[8][9]} Thousands of scientists and other experts volunteer to review the data and compile key findings into "Assessment Reports" for policymakers and the general public;^[10] this has been described as the biggest peer review process in the scientific community.^[11]

The IPCC is an internationally accepted authority on climate change, and its work is widely agreed upon by leading climate scientists as well as governments.^{[12][11]} Its reports play a key role in the United Nations Framework Convention on Climate Change (UNFCCC),^{[13][8]} with the Fifth Assessment Report heavily informing the landmark Paris Agreement in 2015.^[14] The IPCC shared the 2007 Nobel Peace Prize with Al Gore for contributions to the human understanding of climate change.^[15]

The IPCC is governed by its member states, which elect a bureau of scientists to serve for the duration of an assessment cycle (usually six to seven years); the bureau selects experts nominated by governments and observer organisations to prepare IPCC reports.^[16] The IPCC is supported by a secretariat and various "Technical Support Units" from specialised working groups and task forces.^[16]

Following the election of its new bureau in 2015, the IPCC began its sixth assessment cycle, to be completed in 2022. In August 2021, the Physical Science working group of the IPCC published its contribution the Sixth Assessment Report,^[17] which *The Guardian*

Intergovernmental Panel on Climate Change

ipcc INTERGOVERNMENTAL PANEL ON climate change WMO UNEP	
Abbreviation	IPCC
Formation	1988
Type	Panel
Headquarters	<u>Geneva</u> , Switzerland
Chair	<u>Hoesung Lee</u>
Parent organization	<u>World Meteorological Organization</u> <u>United Nations Environment Program</u>
Website	<u>www.ipcc.ch</u> (<u>http://www.ipcc.ch/</u>)

described as the "starkest warning yet" of "major inevitable and irreversible climate changes",^[18] a theme echoed by many newspapers around the world.^[19] On 28 February 2022, the IPCC released its Working Group II report on impacts and adaptation, the second of four parts (Working Groups I, II and III, along with the synthesis report) of its Sixth Assessment Report.^[20]

The Working Group III's "Mitigation of climate change" sub-report to the Sixth Assessment was made available on April 4, 2022,^[21] with much impact.

During this period of the Sixth Assessment Report, the IPCC has released several special reports, including the Special Report on Global Warming of 1.5 °C in 2018, and the Special Report on Climate Change and Land (SRCCL), and the Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC), both in 2019. Consequently, the sixth assessment cycle has been described as the most ambitious in the IPCC's history.^[22]

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Origins and aims

The IPCC developed from an international scientific body, the Advisory Group on Greenhouse Gases set up in 1985 by the International Council of Scientific Unions, the United Nations Environment Programme (UNEP), and the World Meteorological Organization (WMO) to provide recommendations based on current research. This small group of scientists lacked the resources to cover the increasingly complex interdisciplinary nature of climate science. The United States government sought an international convention for restrictions on greenhouse gases, and under the conservative Reagan Administration expressed concern about unrestrained influence from independent scientists or from United Nations bodies such as the UNEP and WMO. The U.S. government was the main force in shaping the IPCC as an autonomous intergovernmental body in which scientists took part both as experts and as official representatives of their governments, which would produce reports backed by all leading relevant scientists, and which then had to gain consensus agreement from every participating government. In this way, the IPCC was formed as a hybrid between a scientific body and an intergovernmental political organisation.^[2]

The United Nations formally endorsed the creation of the IPCC in 1988, citing the fact that "[c]ertain human activities could change global climate patterns, threatening present and future generations with potentially severe economic and social consequences", and that "[c]ontinued growth in atmospheric concentrations of 'greenhouse' gases could produce global warming with an eventual rise in sea levels, the effects of which could be disastrous for mankind if timely steps are not taken at all levels".^[23] To that end, the IPCC

was tasked with reviewing peer-reviewed scientific literature and other relevant publications to provide information on the state of knowledge about climate change and its consequences and impacts.

Organization

The IPCC does not conduct original research, but produces comprehensive assessments, reports on special topics, and methodologies to help countries estimate their emissions and removals through sinks of greenhouse gases. Its assessments build on previous reports, highlighting the trajectory towards the latest knowledge; for example, the wording of the reports from the first to the sixth assessment reflects the growing evidence for a changing climate caused by human activity.

The IPCC has adopted and published "Principles Governing IPCC Work", which states that the IPCC will assess:^[8]

- the risk of human-induced climate change,
- its potential impacts, and
- possible options for prevention.

Pursuant to its governing principles, the IPCC conducts its assessments on a "comprehensive, objective, open and transparent basis" that encompasses all "scientific, technical and socioeconomic information relevant to understanding the scientific basis" of climate change. IPCC reports must be neutral with respect to policy recommendations, but may address the objective scientific, technical and socioeconomic factors relevant to enacting certain policies.^[8]

The IPCC is currently chaired by Korean economist Hoesung Lee, who has served since 8 October 2015 with the election of the new IPCC Bureau,^[24] along with three vice-chairs, Youba Sokona (Mali), Ko Barrett (USA) and Thelma Krug (Brazil).^[25] Before this election, the IPCC was led by Vice-Chair Ismail El Gizouli, who was designated acting Chair after the resignation of Rajendra K. Pachauri in February 2015.^[26] The previous chairs were Rajendra K. Pachauri, elected in May 2002; Robert Watson in 1997; and Bert Bolin in 1988.^[27] The chair is assisted by an elected bureau including vice-chairs and working group co-chairs, and by a secretariat.

The Panel itself is composed of representatives appointed by governments. Participation of delegates with appropriate expertise is encouraged. Plenary sessions of the IPCC and IPCC Working Groups are held at the level of government representatives. Non-Governmental and Intergovernmental Organizations admitted as observer organizations may also attend.^[28] Sessions of the Panel, IPCC Bureau, workshops, expert and lead authors meetings are by invitation only.^[8] About 500 people from 130 countries attended the 48th Session of the Panel in Incheon, Republic of Korea, in October 2018, including 290 government officials and 60 representatives of observer organizations. The opening ceremonies of sessions of the Panel and of Lead Author Meetings are open to media, but otherwise IPCC meetings are closed.

The IPCC is structured as follows:

- IPCC Panel: Meets in plenary session about once a year.^[16] It controls the organization's structure, procedures, and work programme, and accepts and approves IPCC reports. The Panel is the IPCC corporate entity.^[10]
- Chair: Elected by the Panel.
- Secretariat: Oversees and manages all activities. Supported by UNEP and WMO.
- Bureau: Elected by the Panel. Chaired by the Chair. Its 34 members include IPCC Vice-Chairs, Co-Chairs of Working Groups and the Task Force, and Vice-Chairs of the Working Groups.^[29] It provides guidance to the Panel on the scientific and technical aspects of its work.^[30]
- Working Groups: Each has two Co-Chairs, one from the developed and one from developing world, and a technical support unit. Sessions of the Working Group approve the Summary for Policymakers of special reports and working group contributions to an assessment report. Each Working Group has a Bureau comprising its Co-Chairs and Vice-Chairs, who are also members of the IPCC Bureau.
 - Working Group I: Assesses scientific aspects of the climate system and climate change. Co-Chairs: Valérie Masson-Delmotte and Panmao Zhai^[29]
 - Working Group II: Assesses vulnerability of socioeconomic and natural systems to climate change, consequences, and adaptation options. Co-Chairs: Hans-Otto Pörtner and Debra Roberts^[29]
 - Working Group III: Assesses options for limiting greenhouse gas emissions and otherwise mitigating climate change. Co-Chairs: Priyadarshi R. Shukla and Jim Skea^[29]
- Task Force on National Greenhouse Gas Inventories.^[31] Co-Chairs: Kiyoto Tanabe and Eduardo Calvo Buendía
 - Task Force Bureau: Comprises the two Co-Chairs, who are also members of the IPCC Bureau, and 12 members.
- Executive Committee: Comprises the Chair, IPCC Vice-Chairs and the Co-Chairs of the Working Groups and Task Force. Its role includes addressing urgent issues that arise between sessions of the Panel.^[32]

Funding

The IPCC receives funding through a dedicated trust fund, established in 1989 by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO). The trust fund receives annual cash contributions by the WMO, UNEP, and IPCC member governments; payments are voluntary and there is no set amount required. Administrative and operational costs, such as for the secretariat and headquarters, are provided by the WMO, which also sets the IPCC's financial regulations and rules.^[33] The Panel is responsible for considering and adopting by consensus the annual budget.

Assessment reports

The IPCC has published five comprehensive assessment reports reviewing the latest climate science, as well as a number of special reports on particular topics.^[34] These reports are prepared by teams of relevant researchers selected by the Bureau from government nominations. Expert reviewers from a wide range of governments, IPCC observer organizations and other organizations are invited at different stages to comment on various aspects of the drafts.^[35]

The IPCC published its First Assessment Report (FAR) in 1990, a supplementary report in 1992, a Second Assessment Report (SAR) in 1995, a Third Assessment Report (TAR) in 2001, a Fourth Assessment Report (AR4) in 2007^[36] and a Fifth Assessment Report (AR5) in 2014. The IPCC is currently preparing its Sixth Assessment Report (AR6), which is being released in stages and will be completed in 2022.

Each assessment report is in three volumes, corresponding to Working Groups I, II, and III. It is completed by a synthesis report that integrates the working group contributions and any special reports produced in that assessment cycle.

Scope and preparation of the reports

The IPCC does not carry out research nor does it monitor climate related data. Lead authors of IPCC reports assess the available information about climate change based on published sources.^{[37][38]} According to IPCC guidelines, authors should give priority to peer-reviewed sources.^[37] Authors may refer to non-peer-reviewed sources (the "grey literature"), provided that they are of sufficient quality.^[37] Examples of non-peer-reviewed sources include model results, reports from government agencies and non-governmental organizations, and industry journals.^[37] Each subsequent IPCC report notes areas where the science has improved since the previous report and also notes areas where further research is required.

There are generally three stages in the review process:^[37]

- Expert review (6–8 weeks)
- Government/expert review
- Government review of:
 - Summaries for Policymakers
 - Overview Chapters
 - Synthesis Report

Review comments are in an open archive for at least five years.

There are several types of endorsement which documents receive:

- Approval. Material has been subjected to detailed, line by line discussion and agreement.
 - Working Group Summaries for Policymakers are *approved* by their Working Groups.
 - Synthesis Report Summary for Policymakers is *approved* by Panel.
- Adoption. Endorsed section by section (and not line by line).
 - Panel *adopts* Overview Chapters of Methodology Reports.
 - Panel *adopts* IPCC Synthesis Report.
- Acceptance. Not been subject to line by line discussion and agreement, but presents a comprehensive, objective, and balanced view of the subject matter.
 - Working Groups *accept* their reports.
 - Task Force Reports are *accepted* by the Panel.
 - Working Group Summaries for Policymakers are *accepted* by the Panel after group *approval*.

The Panel is responsible for the IPCC and its endorsement of Reports allows it to ensure they meet IPCC standards.

There have been a range of commentaries on the IPCC's procedures, examples of which are discussed later in the article (see also [IPCC Summary for Policymakers](#)). Some of these comments have been supportive,^[39] while others have been critical.^[40] Some commentators have suggested changes to the IPCC's procedures.^[41]

Authors

Each chapter has a number of authors who are responsible for writing and editing the material. A chapter typically has two "coordinating lead authors", ten to fifteen "lead authors", and a somewhat larger number of "contributing authors". The coordinating lead authors are responsible for assembling the contributions of the other authors, ensuring that they meet stylistic and formatting requirements, and reporting to the Working Group chairs. Lead authors are responsible for writing sections of chapters. Contributing authors prepare text, graphs or data for inclusion by the lead authors.^[42]

Authors for the IPCC reports are chosen from a list of researchers prepared by governments and participating organisations, and by the Working Group/Task Force Bureaux, as well as other experts known through their published work. The choice of authors aims for a range of views, expertise and geographical representation, ensuring representation of experts from developing and developed countries and countries with economies in transition.

First assessment report (1990)

The First Assessment Report (FAR) of the Intergovernmental Panel on Climate Change (IPCC) was completed in 1990. It served as the basis of the United Nations Framework Convention on Climate Change (UNFCCC). This report had effects not only on the establishment of the United Nations Framework Convention on Climate Change (UNFCCC), but also on the first conference of the parties (COP), held in Berlin in 1995.^[43] The executive summary of the WG I Summary for Policymakers report said they are certain that emissions resulting from human activities are substantially increasing the atmospheric concentrations of the greenhouse gases, resulting on average in an additional warming of the Earth's surface. They calculated with confidence that CO₂ had been responsible for over half the enhanced greenhouse effect. They predicted that under a "business as usual" (BAU) scenario, global mean temperature would increase by about 0.3 °C per decade during the [21st] century. They judged that global mean surface air temperature had increased by 0.3 to 0.6 °C over the last 100 years, broadly consistent with prediction of climate models, but also of the same magnitude as natural climate variability. The unequivocal detection of the enhanced greenhouse effect was not likely for a decade or more.

Second assessment report (1996)

The Second Assessment Report (SAR) of the Intergovernmental Panel on Climate Change (IPCC), published in 1996, is an assessment of the then available scientific and socio-economic information on climate change. The report was split into four parts: a synthesis to help interpret UNFCCC article 2, *The Science of Climate Change* (Working Group I), *Impacts, Adaptations and Mitigation of Climate Change* (WG II), *Economic and Social Dimensions of Climate Change* (WG III). Each of the last three parts was completed by a separate Working Group (WG), and each has a Summary for Policymakers (SPM) that represents a consensus of national representatives.

The SPM of the WG I report contains the following statements: Greenhouse gas concentrations have continued to increase; anthropogenic aerosols tend to produce negative radiative forcings; climate has changed over the past century (air temperature has increased by between 0.3 and 0.6 °C since the late 19th century; this estimate has not significantly changed since the 1990 report); The balance of evidence suggests a discernible human influence on global climate (considerable progress since the 1990 report in distinguishing between natural and anthropogenic influences on climate, because of: including aerosols; coupled models; pattern-based studies). Climate is expected to continue to change in the future (increasing realism of simulations increases confidence; important uncertainties remain but are taken into account in the range of model projections). Finally, the report stated that there were still many uncertainties (estimates of future emissions and biogeochemical cycling; models; instrument data for model testing, assessment of variability, and detection studies).

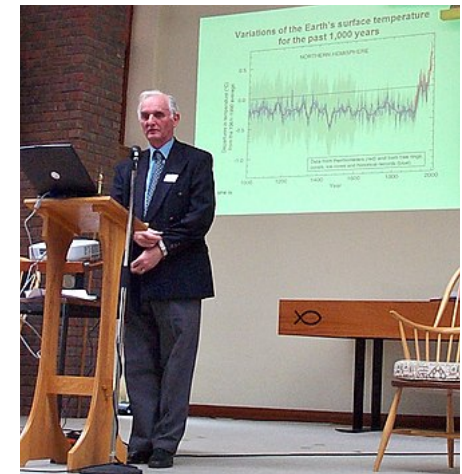
Third assessment report (2001)

The IPCC Third Assessment Report (TAR), *Climate Change 2001*, is an assessment of available scientific and socio-economic information on climate change by the IPCC. The Third Assessment Report is the third of a series of assessments. Statements of the

IPCC or information from the TAR are often used as a reference showing a scientific consensus on the subject of global warming, although a small minority of scientists take issue with the UN assessments (see also Global warming controversy and Politics of global warming). The Third Assessment Report (TAR) was completed in 2001 and consists of four reports, three of them from its Working Groups: Working Group I: The Scientific Basis;^[44] Working Group II: Impacts, Adaptation and Vulnerability;^[45] Working Group III: Mitigation;^[46] Synthesis Report.^[47] A number of the TAR's conclusions are given quantitative estimates of how probable it is that they are correct, e.g., greater than 66% probability of being correct.^[48] These are "Bayesian" probabilities, which are based on an expert assessment of all the available evidence.^{[49][50]}

"Robust findings" of the Synthesis Report include:

- "Observations show Earth's surface is warming. Globally, 1990s very likely warmest decade in instrumental record".^[51] Atmospheric concentrations of anthropogenic (i.e., human-emitted) greenhouse gases have increased substantially.^[51]
- Since the mid-20th century, most of the observed warming is "likely" (greater than 66% probability, based on expert judgement)^[48] due to human activities.^[51]
- Projections based on the *Special Report on Emissions Scenarios* suggest warming over the 21st century at a more rapid rate than that experienced for at least the last 10,000 years.^[51]
- "Projected climate change will have beneficial and adverse effects on both environmental and socioeconomic systems, but the larger the changes and the rate of change in climate, the more the adverse effects predominate."^[51]
- "Ecosystems and species are vulnerable to climate change and other stresses (as illustrated by observed impacts of recent regional temperature changes) and some will be irreversibly damaged or lost."^[51]
- "Greenhouse gas emission reduction (mitigation) actions would lessen the pressures on natural and human systems from climate change."^[51]
- "Adaptation [to the effects of climate change] has the potential to reduce adverse effects of climate change and can often produce immediate ancillary benefits, but will not prevent all damages."^[51] An example of adaptation to climate change is building levees in response to sea level rise.^[52]



IPCC WG1 Co-chair Sir John T. Houghton showing the IPCC fig. 2.20 hockey stick graph at a climate conference in 2005

Fourth assessment report (2007)

Climate Change 2007, the Fourth Assessment Report (AR4) of the United Nations Intergovernmental Panel on Climate Change (IPCC) was published in 2007 and is the fourth in a series of reports intended to assess scientific, technical and socio-economic information concerning climate change, its potential effects, and options for adaptation and mitigation.^[54] The report is the largest

and most detailed summary of the climate change situation ever undertaken, produced by thousands of authors, editors, and reviewers from dozens of countries, citing over 6,000 peer-reviewed scientific studies. People from over 130 countries contributed to the IPCC Fourth Assessment Report, which took 6 years to produce.^[54] Contributors to AR4 included more than 2500 scientific expert reviewers, more than 800 contributing authors, and more than 450 lead authors.^[54]

"Robust findings" of the Synthesis report include:^[55]

- "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level".^[56]
- Most of the global average warming over the past 50 years is "very likely" (greater than 90% probability, based on expert judgement)^[57] due to human activities.^[56]
- "Impacts [of climate change] will very likely increase due to increased frequencies and intensities of some extreme weather events".^[56]
- "Anthropogenic warming and sea level rise would continue for centuries even if GHG emissions were to be reduced sufficiently for GHG concentrations to stabilise, due to the time scales associated with climate processes and feedbacks".^[56] Stabilization of atmospheric greenhouse gas concentrations is discussed in climate change mitigation.
- "Some planned adaptation (of human activities) is occurring now; more extensive adaptation is required to reduce vulnerability to climate change".^[56]
- "Unmitigated climate change would, in the long term, be likely to exceed the capacity of natural, managed and human systems to adapt".^[56]
- "Many impacts [of climate change] can be reduced, delayed or avoided by mitigation".^[56]

The four <i>SRES</i> scenario families ^[53] of the <i>Fourth Assessment Report</i> vs. projected global average surface warming until 2100		
AR4 (Summary; PDF) (http://www.ipcc.ch/pdf/assessment-report/ar4/wg1/ar4-wg1-spm.pdf)	More economic focus	More environmental focus
<u>Globalisation</u> (homogeneous world)	<u>A1</u> rapid economic growth (groups: A1T; A1B; A1FI) 1.4–6.4 °C	<u>B1</u> global environmental sustainability 1.1–2.9 °C
<u>Regionalisation</u> (heterogeneous world)	<u>A2</u> regionally oriented economic development 2.0–5.4 °C	<u>B2</u> local environmental sustainability 1.4–3.8 °C

Fifth assessment report (2014)

The Fifth Assessment Report (AR5) of the United Nations Intergovernmental Panel on Climate Change (IPCC) is the fifth in a series of such reports and was completed in 2014.^[58] As had been the case in the past, the outline of the AR5 was developed through a scoping process which involved climate change experts from all relevant disciplines and users of IPCC reports, in particular representatives from governments. Governments and organizations involved in the Fourth Report were asked to submit comments and observations in writing with the submissions analysed by the panel.^[59] AR5 followed the same general format as of AR4, with

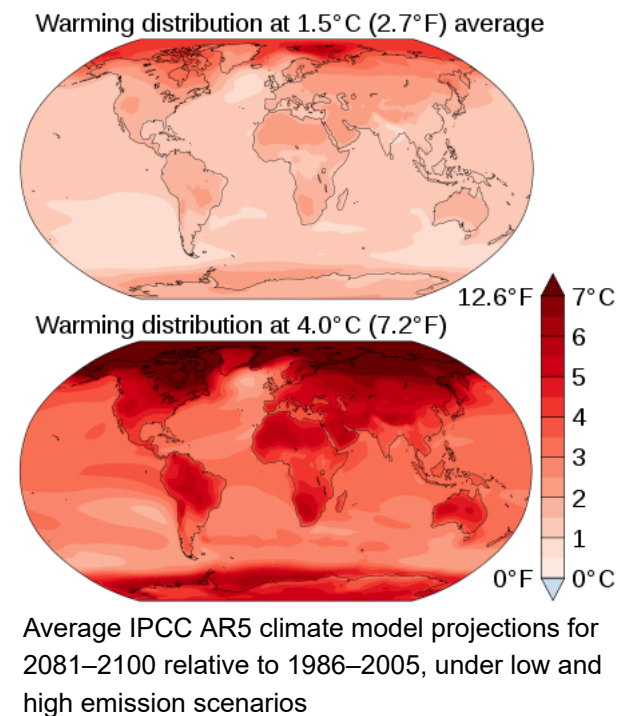
three Working Group reports and a Synthesis report.^[58] The report was delivered in stages, starting with the report from Working Group I in September 2013 with reported on the physical science basis, based on 9,200 peer-reviewed studies.^{[60][61][58]} Projections in AR5 are based on "Representative Concentration Pathways" (RCPs).^[62] The RCPs are consistent with a wide range of possible changes in future anthropogenic greenhouse gas emissions. Projected changes in global mean surface temperature and sea level are given in the main RCP article. The Synthesis Report was released on 2 November 2014,^[63] in time to pave the way for negotiations on reducing carbon emissions at the UN Climate Change Conference in Paris during late 2015.

Conclusions of the fifth assessment report are summarized below:

- Working Group I: "Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia".^[64] "Atmospheric concentrations of carbon dioxide, methane, and nitrous oxide have increased to levels unprecedented in at least the last 800,000 years".^[65] Human influence on the climate system is clear.^[66] It is extremely likely (95–100% probability)^[67] that human influence was the dominant cause of global warming between 1951 and 2010.^[66]
- Working Group II: "Increasing magnitudes of [global] warming increase the likelihood of severe, pervasive, and irreversible impacts".^[68] "A first step towards adaptation to future climate change is reducing vulnerability and exposure to present climate variability".^[69] "The overall risks of climate change impacts can be reduced by limiting the rate and magnitude of climate change"^[68]
- Working Group III: Without new policies to mitigate climate change, projections suggest an increase in global mean temperature in 2100 of 3.7 to 4.8 °C, relative to pre-industrial levels (median values; the range is 2.5 to 7.8 °C including climate uncertainty).^[70] "(T)he current trajectory of global annual and cumulative emissions of GHGs is not consistent with widely discussed goals of limiting global warming at 1.5 to 2 degrees Celsius above the pre-industrial level."^[71] Pledges made as part of the Cancún Agreements are broadly consistent with cost-effective scenarios that give a "likely" chance (66–100% probability) of limiting global warming (in 2100) to below 3 °C, relative to pre-industrial levels.^[72]

Sixth assessment report (2021/2022)

The Sixth Assessment Report (AR6) of the United Nations (UN) Intergovernmental Panel on Climate Change (IPCC) is the sixth in a series of reports which assess scientific, technical, and socio-economic information concerning climate change. Three Working Groups (WG) have been working on the following topics:



1. The Physical Science Basis (WGI)
2. Impacts, Adaptation and Vulnerability (WGII)
3. Mitigation of Climate Change (WGIII).

Of these, the first study was published in 2021, the second report February 2022, and the third in April 2022. The final synthesis report is due to be finished by late 2022.

The first of the three working groups (WGI) published its report on 9 August 2021, *Climate Change 2021: The Physical Science Basis*.^{[73][74]} A total of 234 scientists from 66 countries contributed to this first of three working group reports.^{[75][76]} The report's authors^[77] built on more than 14,000 scientific papers to produce a 3,949-page report, which was then approved by 195 governments.^[78] The Summary for Policymakers (SPM) document was drafted by scientists and agreed to line-by-line by the 195 governments in the IPCC during the five days leading up to 6 August 2021.^[77]

According to the first working group report, it is only possible to avoid warming of 1.5 °C (2.7 °F) or 2.0 °C (3.6 °F) if massive and immediate cuts in greenhouse gas emissions are made.^[73] In a front-page story, *The Guardian* described the report as "its starkest warning yet" of "major inevitable and irreversible climate changes",^[79] a theme echoed by many newspapers^[80] as well as political leaders and activists around the world.

Communications and dissemination activities

Already in the Fifth Assessment Report, the IPCC had enhanced its communications activities, for instance by making the approved report and press release available to registered media under embargo before the release,^[81] and expanding its outreach activities with an outreach calendar.^[82] At the start of the Sixth Assessment Report cycle, the IPCC held an Expert Meeting on Communication in February 2016, bringing together members of the old and new Bureau and Technical Support Units with communications experts and practitioners. This meeting produced a series of recommendations.^[83] Many of these were taken up subsequently by the IPCC, such as bringing people with communications expertise into the Working Group Technical Support Units, and considering communications questions early on in the preparation of reports.

This increasing professionalism in IPCC communications was followed by a significant increase in the media coverage of some IPCC reports such as the Special Report on Global Warming of 1.5°C in 2018 and "Climate Change 2021: The Physical Science Basis" (the Working Group I contribution to the Sixth Assessment Report) in 2021, as well as public interest reflected in the youth and other movements that emerged in 2018.^[84]

The importance of IPCC reports for public awareness of climate change and related policymaking has led to number of academic studies of IPCC communications. The journal "Climatic Change" published a "Topical Collection" on IPCC communications with contributions from communications scientists and IPCC insiders, launched at the annual climate conference COP26 in Glasgow.

[85][86]

Archiving

Papers and electronic files of certain working groups of the IPCC, including reviews and comments on drafts of their Assessment Reports, are archived at the Environmental Science and Public Policy Archives (<https://web.archive.org/web/20100427023820/http://hcl.harvard.edu/collections/ipcc/>) in the Harvard Library.

Other reports

Special reports

In addition to climate assessment reports, the IPCC publishes Special Reports on specific topics. The preparation and approval process for all IPCC Special Reports follows the same procedures as for IPCC Assessment Reports. In the year 2011 two IPCC Special Report were finalized, the Special Report on Renewable Energy Sources and Climate Change Mitigation (SRREN) and the Special Report on Managing Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX). Both Special Reports were requested by governments.^[87]

Special Report on Emissions Scenarios (SRES)

The Special Report on Emissions Scenarios (SRES) is a report by the IPCC which was published in 2000.^[88] The SRES contains "scenarios" of future changes in emissions of greenhouse gases and sulfur dioxide.^[89] One of the uses of the SRES scenarios is to project future changes in climate, e.g., changes in global mean temperature. The SRES scenarios were used in the IPCC's Third^[90] and Fourth Assessment Reports.^[91]

The SRES scenarios are "baseline" (or "reference") scenarios, which means that they do not take into account any current or future measures to limit greenhouse gas (GHG) emissions (e.g., the Kyoto Protocol to the United Nations Framework Convention on Climate Change).^[92] SRES emissions projections are broadly comparable in range to the baseline projections that have been developed by the scientific community.^[93]

Comments on the SRES

There have been a number of comments on the SRES. Parson *et al.* (2007)^[94] stated that the SRES represented "a substantial

advance from prior scenarios". At the same time, there have been criticisms of the SRES.^[95]

The most prominently publicized criticism of SRES focused on the fact that all but one of the participating models compared gross domestic product (GDP) across regions using market exchange rates (MER), instead of the more correct purchasing-power parity (PPP) approach.^[96] This criticism is discussed in the main SRES article.

Special report on renewable energy sources and climate change mitigation (SRREN)

This report assesses existing literature on renewable energy commercialisation for the mitigation of climate change.^[97] It was published in 2012 and covers the six most important renewable energy technologies in a transition, as well as their integration into present and future energy systems. It also takes into consideration the environmental and social consequences associated with these technologies, the cost and strategies to overcome technical as well as non-technical obstacles to their application and diffusion.

More than 130 authors from all over the world contributed to the preparation of IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation (SRREN) on a voluntary basis – not to mention more than 100 scientists, who served as contributing authors.^{[87][97]}

Special Report on managing the risks of extreme events and disasters to advance climate change adaptation (SREX)

The report (<https://wg1.ipcc.ch/srex/>) was published in 2012. It assesses the effect that climate change has on the threat of natural disasters and how nations can better manage an expected change in the frequency of occurrence and intensity of severe weather patterns. It aims to become a resource for decision-makers to prepare more effectively for managing the risks of these events. A potentially important area for consideration is also the detection of trends in extreme events and the attribution of these trends to human influence. The full report, 594 pages in length, may be found here (https://www.ipcc.ch/pdf/special-reports/srex/SREX_Full_Report.pdf) in PDF form.

More than 80 authors, 19 review editors, and more than 100 contributing authors from all over the world contributed to the preparation of SREX.^{[87][98]}

Special Report on Global Warming of 1.5 °C (SR15)

When the Paris Agreement was adopted, the UNFCCC invited the Intergovernmental Panel on Climate Change to write a special report on "How can humanity prevent the global temperature rise more than 1.5 degrees above pre-industrial level".^[99] The completed report, Special Report on Global Warming of 1.5 °C (SR15), was released on 8 October 2018. Its full title is "Global Warming of 1.5 °C, an IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global

greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty".^[99]

The finished report summarizes the findings of scientists, showing that maintaining a temperature rise to below 1.5 °C remains possible, but only through "rapid and far-reaching transitions in energy, land, urban and infrastructure..., and industrial systems".^{[99][100]} Meeting the Paris target of 1.5 °C (2.7 °F) is possible but would require "deep emissions reductions", "rapid",^[100] "far-reaching and unprecedented changes in all aspects of society".^[101] In order to achieve the 1.5 °C target, CO₂ emissions must decline by 45% (relative to 2010 levels) by 2030, reaching net zero by around 2050. Deep reductions in non-CO₂ emissions (such as nitrous oxide and methane) will also be required to limit warming to 1.5 °C. Under the pledges of the countries entering the Paris Accord, a sharp rise of 3.1 to 3.7 °C is still expected to occur by 2100. Holding this rise to 1.5 °C avoids the worst effects of a rise by even 2 °C. However, a warming of even 1.5 degrees will still result in large-scale drought, famine, heat stress, species die-off, loss of entire ecosystems, and loss of habitable land, throwing more than 100 million into poverty. Effects will be most drastic in arid regions including the Middle East and the Sahel in Africa, where fresh water will remain in some areas following a 1.5 °C rise in temperatures but are expected to dry up completely if the rise reaches 2 °C.^{[102][103][104]}

Special Report on climate change and land (SRCCL)

The final draft of the "Special Report on climate change and land" (SRCCL)—with the full title, "Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems" was published online on 7 August 2019.^{[105][106]}

Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC)

The "Special Report on the Ocean and Cryosphere in a Changing Climate" (SROCC) was approved on 25 September 2019 in Monaco.^[107] Among other findings, the report concluded that sea level rises could be up to two feet higher by the year 2100, even if efforts to reduce greenhouse gas emissions and to limit global warming are successful; coastal cities across the world could see so-called "storm[s] of the century" at least once a year.^[108]

Methodology reports

Within IPCC the National Greenhouse Gas Inventory Program develops methodologies to estimate emissions of greenhouse gases.^[109] This has been undertaken since 1991 by the IPCC WGI in close collaboration with the Organisation for Economic Co-operation and Development and the International Energy Agency. The objectives of the National Greenhouse Gas Inventory Program are:

- to develop and refine an internationally agreed methodology and software for the calculation and reporting of national greenhouse gas emissions and removals; and
- to encourage the widespread use of this methodology by countries participating in the IPCC and by signatories of the UNFCCC.

Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories

The 1996 Guidelines for National Greenhouse Gas Inventories provide the methodological basis for the estimation of national greenhouse gas emissions inventories.^[110] Over time these guidelines have been completed with good practice reports: *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* and *Good Practice Guidance for Land Use, Land-Use Change and Forestry*.

The 1996 guidelines and the two good practice reports are to be used by parties to the UNFCCC and to the Kyoto Protocol in their annual submissions of national greenhouse gas inventories.

2006 IPCC Guidelines for National Greenhouse Gas Inventories

The 2006 *IPCC Guidelines for National Greenhouse Gas Inventories* is the latest version of these emission estimation methodologies, including a large number of default emission factors.^[111] Although the IPCC prepared this new version of the guidelines on request of the parties to the UNFCCC, the methods have not yet been officially accepted for use in national greenhouse gas emissions reporting under the UNFCCC and the Kyoto Protocol.^[112]

Other activities

The IPCC concentrates its activities on the tasks allotted to it by the relevant WMO Executive Council and UNEP Governing Council resolutions and decisions as well as on actions in support of the UNFCCC process.^[8] While the preparation of the assessment reports is a major IPCC function, it also supports other activities, such as the Data Distribution Centre^[113] and the National Greenhouse Gas Inventories Programme,^[114] required under the UNFCCC. This involves publishing default emission factors, which are factors used to derive emissions estimates based on the levels of fuel consumption, industrial production and so on.

The IPCC also often answers inquiries from the UNFCCC Subsidiary Body for Scientific and Technological Advice (SBSTA).

Awards

Nobel Peace Prize in 2007

In December 2007, the IPCC was awarded the Nobel Peace Prize "for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change". The award is shared with former U.S. Vice-President Al Gore for his work on climate change and the documentary *An Inconvenient Truth*.^[115]

Criticism

There is widespread support for the IPCC in the scientific community, which is reflected in publications by other scientific bodies^{[116][117]} 2008^[118] and 2009^{[119][120]} and experts;^[121] however, critiques of the IPCC have been made.^[122]

Since 2010, the IPCC has come under yet unparalleled public and political scrutiny.^[123] The global IPCC consensus approach has been challenged internally^{[124][125]} and externally, for example, during the 2009 Climatic Research Unit email controversy ("Climategate").^[126] It is contested by some as an information monopoly with results for both the quality and the impact of the IPCC work as such.^{[124][127]}

Conservative nature of IPCC reports

Some critics have contended that the IPCC reports tend to be conservative by consistently underestimating the pace and impacts of global warming,^[128] and report only the "lowest common denominator" findings.^[129]

On the eve of the publication of IPCC's Fourth Assessment Report in 2007 another study was published suggesting that temperatures and sea levels have been rising at or above the maximum rates proposed during IPCC's 2001 Third Assessment Report. The study compared IPCC 2001 projections on temperature and sea level change with observations. Over the six years studied, the actual temperature rise was near the top end of the range given by IPCC's 2001 projection, and the actual sea level rise was above the top of the range of the IPCC projection.^{[130][131]}

Another example of scientific research which suggests that previous estimates by the IPCC, far from overstating dangers and risks, have actually understated them is a study on projected rises in sea levels. When the researchers' analysis was "applied to the possible scenarios outlined by the Intergovernmental Panel on Climate Change (IPCC), the researchers found that in 2100 sea levels would be 0.5–1.4 m [50–140 cm] above 1990 levels. These values are much greater than the 9–88 cm as projected by the IPCC itself in its Third Assessment Report, published in 2001". This may have been due, in part, to the expanding human understanding of climate.^{[132][133]}

Greg Holland from the National Center for Atmospheric Research, who reviewed a multi-meter sea level rise study by Jim Hansen,

noted "*There is no doubt that the sea level rise, within the IPCC, is a very conservative number, so the truth lies somewhere between IPCC and Jim.*"^[134]

In reporting criticism by some scientists that IPCC's then-impending January 2007 report understates certain risks, particularly sea level rises, an AP story quoted Stefan Rahmstorf, professor of physics and oceanography at Potsdam University as saying "In a way, it is one of the strengths of the IPCC to be very conservative and cautious and not overstate any climate change risk".^[135]

In his December 2006 book, *Hell and High Water: Global Warming*, and in an interview on Fox News on 31 January 2007, energy expert Joseph Romm noted that the IPCC Fourth Assessment Report is already out of date and omits recent observations and factors contributing to global warming, such as the release of greenhouse gases from thawing tundra.^[136]

Political influence on the IPCC has been documented by the release of a memo by ExxonMobil to the Bush administration, and its effects on the IPCC's leadership. The memo led to strong Bush administration lobbying, evidently at the behest of ExxonMobil, to oust Robert Watson, a climate scientist, from the IPCC chairmanship, and to have him replaced by Rajendra Pachauri, who was seen at the time as more mild-mannered and industry-friendly.^{[137][138]}

Procedures

Michael Oppenheimer, a long-time participant in the IPCC and coordinating lead author of the Fifth Assessment Report conceded in *Science Magazine's State of the Planet 2008–2009* some limitations of the IPCC consensus approach and asks for concurring, smaller assessments of special problems instead of the large scale approach as in the previous IPCC assessment reports.^[125] It has become more important to provide a broader exploration of uncertainties.^[125] Others see as well mixed blessings of the drive for consensus within the IPCC process and ask to include dissenting or minority positions^[139] or to improve statements about uncertainties.^{[140][141]}

The IPCC process on climate change and its efficiency and success has been compared with dealings with other environmental challenges (compare Ozone depletion and global warming). In case of the Ozone depletion, global regulation based on the Montreal Protocol has been successful. In case of Climate Change, the Kyoto Protocol failed.^[142] The Ozone case was used to assess the efficiency of the IPCC process.^[143] The lockstep situation of the IPCC is having built a broad science consensus while states and governments still follow different, if not opposing goals.^[144] The underlying linear model of policy-making of *the more knowledge we have, the better the political response will be* is being doubted.^{[144][145]}

According to Sheldon Ungar's comparison with global warming, the actors in the ozone depletion case had a better understanding of scientific ignorance and uncertainties.^[146] The ozone case communicated to lay persons "with easy-to-understand bridging metaphors derived from the popular culture" and related to "immediate risks with everyday relevance", while the public opinion on climate change sees no imminent danger.^[146] The stepwise mitigation of the ozone layer challenge was based as well on successfully

reducing regional burden sharing conflicts.^[143] In case of the IPCC conclusions and the failure of the Kyoto Protocol, varying regional cost-benefit analysis and burden-sharing conflicts with regard to the distribution of emission reductions remain an unsolved problem.^[142] In the UK, a report for a House of Lords committee asked to urge the IPCC to involve better assessments of costs and benefits of climate change,^[147] but the Stern Review, ordered by the UK government, made a stronger argument in favor to combat human-made climate change.^[148]

Outdatedness of reports

Since the IPCC does not carry out its own research, it operates on the basis of scientific papers and independently documented results from other scientific bodies, and its schedule for producing reports requires a deadline for submissions prior to the report's final release. In principle, this means that any significant new evidence or events that change our understanding of climate science between this deadline and publication of an IPCC report cannot be included. In an area of science where our scientific understanding is rapidly changing, this has been raised as a serious shortcoming in a body which is widely regarded as the ultimate authority on the science.^[149] However, there has generally been a steady evolution of key findings and levels of scientific confidence from one assessment report to the next.^[150]

The submission deadlines for the Fourth Assessment Report (AR4) differed for the reports of each Working Group. Deadlines for the Working Group I report were adjusted during the drafting and review process in order to ensure that reviewers had access to unpublished material being cited by the authors. The final deadline for cited publications was 24 July 2006.^[151] The final WG I report was released on 30 April 2007 and the final AR4 Synthesis Report was released on 17 November 2007. Rajendra Pachauri, the IPCC chair, admitted at the launch of this report that since the IPCC began work on it, scientists have recorded "much stronger trends in climate change", like the unforeseen dramatic melting of polar ice in the summer of 2007,^[152] and added, "that means you better start with intervention much earlier".^[153]

Burden on participating scientists

Scientists who participate in the IPCC assessment process do so without any compensation other than the normal salaries they receive from their home institutions. The process is labor-intensive, diverting time and resources from participating scientists' research programs.^[154] Concerns have been raised that the large uncompensated time commitment and disruption to their own research may discourage qualified scientists from participating.^[155]

Lack of error correction after publication

In May 2010, Pachauri noted that the IPCC currently had no process for responding to errors or flaws once it issued a report. The problem, according to Pachauri, was that once a report was issued the panels of scientists producing the reports were disbanded.^[156]

Proposed organizational overhaul

In February 2010, in response to controversies regarding claims in the *Fourth Assessment Report*,^{[157][158]} five climate scientists – all contributing or lead IPCC report authors – wrote in the journal *Nature* calling for changes to the IPCC. They suggested a range of new organizational options, from tightening the selection of lead authors and contributors, to dumping it in favor of a small permanent body, or even turning the whole climate science assessment process into a *moderated* "living" Wikipedia-IPCC.^{[159][160]} Other recommendations included that the panel employ a full-time staff and remove government oversight from its processes to avoid political interference.^[161]

Reframing of scientific research

The 2018 report *What Lies Beneath* by the *Breakthrough – National Centre for Climate Restoration* urges the IPCC, the wider UNFCCC negotiations, and national policy makers to change their approach. The authors note, "We urgently require a reframing of scientific research within an existential risk-management framework."^[162]

Reviews

InterAcademy Council review

In March 2010, at the invitation of the United Nations secretary-general and the chair of the IPCC, the *InterAcademy Council* (IAC) was asked to review the IPCC's processes for developing its reports.^{[163][164]} The IAC panel, chaired by *Harold Tafler Shapiro*, convened on 14 May 2010 and released its report on 1 September 2010.^{[156][165]}

The IAC found that, "The IPCC assessment process has been successful overall". The panel, however, made seven formal recommendations for improving the IPCC's assessment process, including:

1. establish an executive committee;
2. elect an executive director whose term would only last for one assessment;
3. encourage review editors to ensure that all reviewer comments are adequately considered and genuine controversies are adequately reflected in the assessment reports;
4. adopt a better process for responding to reviewer comments;
5. working groups should use a qualitative level-of-understanding scale in the Summary for Policy Makers and Technical Summary;
6. "Quantitative probabilities (as in the likelihood scale) should be used to describe the probability of well-defined outcomes only when there is sufficient evidence"; and

7. implement a communications plan that emphasizes transparency and establish guidelines for who can speak on behalf of the organization.^[166]

The panel also advised that the IPCC avoid appearing to advocate specific policies in response to its scientific conclusions.^[167] Commenting on the IAC report, *Nature News* noted that "The proposals were met with a largely favourable response from climate researchers who are eager to move on after the media scandals and credibility challenges that have rocked the United Nations body during the past nine months".^[168]

Endorsements

Various scientific bodies have issued official statements endorsing and concurring with the findings of the IPCC.

- Joint science academies' statement of 2001. "The work of the Intergovernmental Panel on Climate Change (IPCC) represents the consensus of the international scientific community on climate change science. We recognise IPCC as the world's most reliable source of information on climate change and its causes, and we endorse its method of achieving this consensus".^[116]
- Canadian Foundation for Climate and Atmospheric Sciences. "We concur with the climate science assessment of the Intergovernmental Panel on Climate Change (IPCC) in 2001 ... We endorse the conclusions of the IPCC assessment..."^[169]
- Canadian Meteorological and Oceanographic Society. "CMOS endorses the process of periodic climate science assessment carried out by the Intergovernmental Panel on Climate Change and supports the conclusion, in its Third Assessment Report, which states that the balance of evidence suggests a discernible human influence on global climate."^[170]
- European Geosciences Union. "The Intergovernmental Panel on Climate Change ... is the main representative of the global scientific community [The] IPCC third assessment report ... represents the state-of-the-art of climate science supported by the major science academies around the world and by the vast majority of scientific researchers and investigations as documented by the peer-reviewed scientific literature".^[171]
- International Council for Science (ICSU). "...the IPCC 4th Assessment Report represents the most comprehensive international scientific assessment ever conducted. This assessment reflects the current collective knowledge on the climate system, its evolution to date, and its anticipated future development".^[172]
- National Oceanic and Atmospheric Administration (US). "Internationally, the Intergovernmental Panel on Climate Change (IPCC)... is the most senior and authoritative body providing scientific advice to global policy makers".^[173]
- United States National Research Council. "The IPCC Third Assessment Report'] conclusion that most of the observed warming of the last 50 years is likely to have been due to the increase in greenhouse gas concentrations accurately reflects the current thinking of the scientific community on this issue".^[174]
- Network of African Science Academies. "The IPCC should be congratulated for the contribution it has made to public understanding of the nexus that exists between energy, climate and sustainability".^[175]

- Royal Meteorological Society, in response to the release of the Fourth Assessment Report, referred to the IPCC as "The world's best climate scientists".^[176]
- Stratigraphy Commission of the Geological Society of London. "The most authoritative assessment of climate change in the near future is provided by the Inter-Governmental Panel for Climate Change".^[177]

See also

- United Nations Framework Convention on Climate Change – 1994 international environmental treaty
- Kyoto Protocol – 1997 international treaty to reduce greenhouse gas emissions
- Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services – Towards science-led government policy
- Post-Kyoto Protocol negotiations on greenhouse gas emissions – Towards multi-lateral commitments

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External links

- Official website (<https://www.ipcc.ch/>)
- IPCC Data Distribution Centre (<http://www.ipcc-data.org/>) Climate data and guidance on its use.

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