

IPCC: accomplishments, controversies and challenges

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The Intergovernmental Panel on Climate Change (IPCC) has successfully produced four assessment reports since 1990 along with a number of special reports and greenhouse gas inventory guidelines. It has very rigorous and robust procedures and guidelines for preparing the assessment reports largely based on synthesis of peer-reviewed and published scientific literature. IPCC has attracted controversy since the Second Assessment Report of 1995. The recent controversies surrounding the IPCC reports surfaced nearly two years after the release of the report in 2007, especially in the wake of the crucial Copenhagen Climate Convention. Many of the controversies can be traced to the use of information sourced from reports published outside the scientific journals such as reports of the World Wildlife Fund. It is true that there are a few errors in the IPCC reports, which may have escaped the multilayered rigorous review process. Many of the errors found in the main reports, which are over a thousand page each, have not been quoted in the crucial and most referred Summary for Policy Makers. IPCC may have to develop a more robust policy for sourcing literature published outside the scientific journals. The United Nations Secretary General has requested the prestigious Inter-Academy Council to review the IPCC principles, procedures and guidelines. The controversies raised in the recent past do not in any way change the main conclusions of the IPCC Assessment Report.

Keywords: Climate change, controversies, IPCC, peer-review, principles, procedures.

AS one of the most important global environmental challenges facing humanity, climate change has deservedly received the collective attention of policy makers, industry, non-governmental organizations (NGOs), citizens, mass media and, of course, the scientific community. This is evidenced by the fact that climate change was at the centre of the global agenda before, during and even after the Copenhagen Climate Convention in December 2009. Due to long-term and irreversible consequences for human and natural ecosystems, climate change is a problem which requires a global response. It was in response to this need that the Intergovernmental Panel on Climate Change (IPCC) was established in 1988 under the auspices of the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) with the purpose of assessing the scientific, technical and socioeconomic information relevant for the understanding of the risk of human-induced climate change. IPCC does not carry out new research nor does it monitor climate-related data. It bases its assessment mainly on published and peer-reviewed scientific and technical literature. The

goal of these assessments is to inform international policy and negotiations on climate-related issues. Since its inception, IPCC has produced several special reports and technical papers as well as the all important four assessments on climate change. Of these, the IPCC Assessment Report 4 (AR4) has been most influential in changing the global opinion about climate change leading up to the Copenhagen Climate Convention. Unfortunately, this report has also raised controversy and received negative coverage in the media, in political circles and even in certain sections of the scientific community.

This sensationalized reporting, selectively highlighting just a few of the many important findings painstakingly compiled by the IPCC, has perhaps given rise to a distorted image of the functioning of IPCC. More importantly, there has been little or no coverage to the exceptionally thorough, rigorous, transparent and participatory process involved in the preparation of the IPCC assessment reports. *Nature* published two editorials recently: 'IPCC: cherish it, tweak it or scrap it?'¹ and 'Climate of fear'². *Current Science* also carried an editorial titled 'Climate science: drowned in the noise'³. *Science* had an editorial titled 'The IPCC must maintain its rigor'⁴.

This article reports the unique and unprecedented scientific effort and collaboration that forms the foundation

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of the working ethics of every report compiled by the IPCC. In this article, an attempt is made to present my views as an author involved in eight reports of the IPCC⁵. Part I of the article briefly explains the organization, its principles, procedures and achievements. Part II deals with the controversies and future of the IPCC.

Part I: Rationale for IPCC

Climate change assessment involves synthesis of knowledge on past and current global, continental and national level greenhouse gas (GHG) emissions and projections as well as modelling of ocean–earth–atmosphere, observed climate change and its detection and attribution, climate change projections, attributing causes, including the role of GHGs in the projected climate change, the impacts of climate change on natural and socio-economic systems along with an assessment of adaptation strategies and mitigation opportunities, their costs and benefits, related technologies and policies. Climate change and its impacts are long-term and global in nature. Regions contributing most to GHG build-up could be different from the regions most vulnerable to the impacts of climate change. The implications of GHG emissions of present generation could affect the coming generations. In addition, climate science is an emerging field of study with an enormous amount of complex literature and often with conflicting findings, high uncertainties, scientific evidence and model projections being continually generated at a very rapid rate. Climate change is also one of the best examples for interdisciplinary studies. This is evidenced by the birth of a large number of international journals dealing with climate change in the last two decades. Scientific literature on climate change is published not only at the global level in international journals in English, but also, in national and regional journals and also in many languages. Thus, the participation of the global scientific community, which can best happen in a United Nation (UN) based system, is essential for a comprehensive assessment of climate change science and literature. This is the rationale behind the need for an international scientific panel to assess climate change. IPCC is an intergovernmental participatory process and is governed by UN styled rules and regulations.

Assessment reports prepared by IPCC

The first report of IPCC was released in 1990, the AR4 was released in 2007 and the next or the Fifth Assessment Report (AR5) is due in 2014. Nearly 490 experts from 130 countries served as lead authors for the AR4. Another 800 served as contributing authors. About 2500 experts provided more than 90,000 review comments. IPCC consists of three working groups (WG) and a GHG inventory taskforce. WGs focus on the following aspects.

- WGI: deals with the physical science, projections and attributions of climate change.
- WGII: assesses the impacts of climate change on natural ecosystems, socio-economic systems; the vulnerability of the systems; as well as the potential adaptation strategies and practices.
- WGIII: examines technology and policy options to mitigate climate change along with an assessment of related costs and benefits.

The GHG inventory taskforce prepares GHG inventory guidelines for countries to estimate and report GHG emissions.

The WG report consists of about thousand pages divided into 11–20 chapters. To simplify these voluminous reports to policy makers, IPCC also produces the following:

- Technical summary of 50–70 pages highlighting the key findings of each assessment report.
- Summary for policy makers (SPM), a 10–20 page summary highlighting the most important findings of relevance to policy makers.
- Synthesis report, a short summary synthesizing and integrating the key findings of all the three WG reports for policy makers.

Institutional structures and procedures of IPCC

Institutional structure

IPCC Secretariat, located at the WMO headquarters in Geneva, is a small organization with only a chairman, a secretary and a small support staff in contrast to a typical UN organization that has thousands of scientists, economists and managers at their headquarters. IPCC has several co-chairs and a bureau with members nominated from different countries. WGs are hosted in different countries. WGI of AR5 is being hosted by Switzerland (previously USA), WGII by the USA (previously UK) and WGIII by Germany (previously the Netherlands). Though developing countries may also host WGs, none of them have volunteered so far, probably due to the costs involved. The host country has no advantage in decisions on the report preparation, selection of authors, contents of the reports or in the approval process. The most powerful body of the IPCC that is responsible for making all the crucial decisions, starting from the contents and procedures to the final approval of the reports, is the ‘IPCC panel’ that consists of representatives of all the governments under the UN. This IPCC panel meets periodically and takes all the decisions which are binding. So IPCC is not an organization with its own agenda to promote or make its own rules, it is continuously controlled and supervised by this panel.

Procedures

The procedures of IPCC, akin to a typical UN organization, are complex, participatory and representative in nature. The IPCC follows the 'Principles governing the IPCC work' (<http://www.ipcc.ch/pdf/press/ipcc-statement-principles-procedures-02-2010.pdf>) established by the IPCC panel.

Request for the assessment reports: The United Nations Framework on Convention on Climate Change (UNFCCC) addresses problems of climate change. Normally the request for assessment reports comes from the UNFCCC directly or through its SBSTA (Subsidiary Body for Scientific and Technical Advice). UNFCCC requests for periodic assessment reports, development of GHG inventory guidelines, special reports and technical papers.

Contents of the assessment reports: IPCC panel suggests a broad outline for each of the WG reports – to be elaborated through a scoping meeting of the experts invited by the IPCC, and the panel finally approves the detailed contents and outlines of the WG reports. Thus, what is included in the IPCC reports is decided by the governments and not by a few IPCC experts.

Selection of authors: IPCC asks the national IPCC focal points located in the ministries in all the UN member countries to nominate experts from their countries. Nominations are also sought from UN organizations such as Food and Agricultural Organization (FAO) and UNEP or other organizations. Each WG normally selects the authors for their report from the list of government nominees. Often, names of experts from outside the lists nominated by the governments may also be selected, to meet any gaps in technical expertise. The final list of selected authors for each WG report is approved by the WG bureau which is a representative body of the governments, keeping in mind factors such as regional and gender representation, in addition to technical expertise in the field. The country level representation is often a contentious issue since some countries and regions complain about under-representation. It can be observed from Table 1 that India and China account for about 5% of authors each, whereas USA accounts for 18% and dominates the list of authors. The domination of USA is not overwhelming, even though it might overwhelmingly dominate the international scientific literature on climate change.

Given here are the categories of authors:

- *WG co-chairs* one representing the developing countries and the other the developed countries, co-ordinate the preparation, review and finalization of all the

chapters; ensure consistency across chapters and also take responsibility for getting the reports approved by the IPCC panel.

- *Coordinating lead author (CLA)* normally each chapter has two CLAs, one from the developed and the other from developing countries, who synthesize contributions of the lead authors and ensure the scientific quality of the chapter.
- *Lead authors (LA)* are at the heart of the IPCC assessments, since they review, evaluate and synthesize all the peer-reviewed as well as other published literature relevant to the chapter.
- *Contributory authors (CA)* normally assist the LAs in preparing a certain section of the chapter, but do not participate in the author meetings or approval process.
- *Review editor (RE)* ensures that all the comments from the multilayered review process are adequately addressed by the chapter authors; one from developing and the other from developed countries have to finally certify that they are satisfied with the chapter with respect to addressing the comments and suggestions made by the reviewers. RE is not associated with the preparation of the chapter.

Preparation of the chapter: The main task of the authors of the chapter is to review, evaluate and synthesize the scientific literature relevant to the chapter. The normal guidelines in the preparation of the chapter are as follows.

(i) *Peer-reviewed scientific literature* is the main source of information for data, model projections and findings for the assessment. This is the very foundation of the IPCC reports as information for assessments should normally come from the peer-reviewed and published scientific articles. The most common complaint is that the IPCC report shows over-dependence on scientific journals published in English language and ignores literature in other languages such as Chinese, Portuguese, Russian, Spanish, etc. With respect to non-peer reviewed literature, which could include books and reports from national and international agencies, UN organizations, NGOs, etc., there is a clear policy wherein the authors have to make a judgement on the scientific validity of such information. Such literature quoted must be accessible to the scientific community or the reviewers. Most of the recent controversy surrounding IPCC seems to originate from sourcing of information from non-peer reviewed literature, be it about the Himalayan glacier retreat or Amazon die-back or link between climate change and frequency of extreme events.

(ii) *Policy relevant but not policy prescriptive* is the byword for all IPCC authors. IPCC is only supposed to evaluate and synthesize literature to generate reports that assist policy makers, not to make policy recommendations. It is also supposed to provide diverse viewpoints, if

Table 1. Number of authors from selected countries and regions (CLA: convening lead author, LA: lead author) contributing to Assessment Report 4 (AR4) of 2007

| Countries | WG I | | WG II | | WG III | | Total |
|-----------|------|-----|-------|-----|--------|-----|-------------|
| | CLA | LA | CLA | LA | CLA | LA | |
| India | 0 | 5 | 3 | 4 | 3 | 5 | 20 (4.1%) |
| China | 1 | 7 | 2 | 4 | 1 | 11 | 26 (5.3%) |
| Brazil | 0 | 2 | 1 | 1 | 1 | 2 | 7 (1.4%) |
| Japan | 0 | 6 | 2 | 3 | 1 | 12 | 24 (5.0%) |
| UK | 3 | 13 | 4 | 10 | 2 | 6 | 38 (7.7%) |
| USA | 7 | 28 | 6 | 18 | 6 | 25 | 90 (18.4%) |
| Africa | 1 | 6 | 5 | 6 | 0 | 16 | 34 (7.0%) |
| Others | 9 | 55 | 25 | 85 | 11 | 65 | 250 (51.1%) |
| Total | 21 | 122 | 48 | 131 | 25 | 142 | 489 100.0% |

they exist in the literature, and present the merits and demerits of a technology or policy. IPCC is rarely accused of being directly policy-prescriptive, though many argue that IPCC findings have been misused or abused by some governments.

(iii) *Referencing of information* is very critical for all information, data and maps used in the IPCC assessments. Normally there is a limit on the length of the main chapter but there is no limit on the length of the listing of references. It is common to find that in many chapters, the pages devoted to references is significantly more in number than that of the chapter itself and any typical journal article. IPCC chapters act as a goldmine of references on climate science for any student or a researcher.

(iv) *Review process* adopted by the IPCC is unique in scientific publication. When a paper is sent to any peer-reviewed journal, it is usually the editor who makes the first judgement on the suitability of the paper for the journal. It is then sent to 2–3 reviewers. In contrast, the review process of the IPCC is unprecedented in science and is very elaborate and multilayered. The following procedure is used in this process.

- Chapter lead authors: About 7–10 scientists who are authors of the chapter review the first version of a chapter.
- WG authors review: The draft chapters will be shared with all the authors of the WG (100–150 authors) for review and comments.
- Expert review: This is the process where the chapters are sent to hundreds of experts who are not authors of the IPCC report. Usually, for each chapter of 8–10 pages, the authors often receive thousands of comments.
- Experts–government review: This is the most important step of the IPCC review process, where hundreds of independent experts and all the governments review the chapters. Many governments constitute national expert committees for different WGs and chapters, collect all the comments, synthesize and send them to IPCC. The reports are also sent to UN organi-

zations, NGOs, etc. This is a massive process, with each chapter often reviewed by hundreds of experts and governments. The compilation of comments for many chapters is usually several times longer than the chapter itself. During this process, no section of a chapter escapes the attention of the reviewers. It is very rare to find an error such as the one related to the rate of melting of Himalayan glaciers.

- Government review: This is the penultimate step to the final approval of the chapters and the reports, wherein each of the governments ensure that their comments have been adequately addressed.
- Review editors: They are usually two in number per chapter and ensure that the comments of the governments and experts are adequately considered and the chapters are appropriately modified.
- Transparency in addressing all comments: This is one of the critical steps in the IPCC process, the response of the teams of authors for each chapter to each comment is available at the IPCC for verification by any government or expert. The comments are either accepted or rejected. If a comment is rejected, the authors explain the rationale, usually based on published literature.

Approval process: The reports prepared by the authors and the WGs go through an elaborate approval process. In this process, the representatives of all the governments in the IPCC panel participate in plenary meetings to consider and approve the WG reports and the SPM.

(i) *Summary for policy makers:* SPM is prepared by the CLAs and the co-chairs of WG. It is usually 15–20 pages long and consists of short paragraphs, diagrams, maps and tables. The IPCC plenary consisting of representatives of all the governments, often 150–190 in number, discuss each paragraph, figure or table, asking questions and seeking clarifications from the authors before it is approved. Very often, some contentious paragraphs take several days to find a consensus among the government representatives. Here, very often, governments try to interpret paragraphs keeping their national

interests in mind. Very often, different groups of countries make alternate and often conflicting suggestions on the wording of a paragraph. Since every government present at the IPCC plenary has to agree, very often some of the paragraphs get diluted in the process of approval to reflect the diverse views of the governments. However, the IPCC authors also have to approve the wording of the paragraph agreed by the governments based on the scientific literature. IPCC authors often complain of the narrow national, often conflicting interests expressed by the governments. Sometimes a compromise formulation of a paragraph is worked out by the governments, much to the dislike of the authors. Controversial issues such as the glacial melt cannot pass the approval process, since governments would have questioned the literature. However, some controversial issues such as the decline of crop productivity by 50% in rainfed regions of North Africa by 2020 found its way through the approval process. This shows that even though the approval process is rigorous, tedious, contentious and lengthy, some paragraphs may go through the approval process, even though they are not based on adequate robust scientific literature. Such instances are very rare.

(ii) *Approval of main report:* Each WG report is about 1000 pages. Once the SPM which is based on the main chapters is approved, the WG report is also approved by the IPCC plenary. However, the governments can raise an objection on any paragraph, figure, or map given in the main report even at this stage. Controversial issues such as the melting of Himalayan glaciers, reduction of crop yields in Africa by 2020, increased losses due to hurricanes resulting from climate change have not been identified or questioned by the governments or experts at any stage of the complex process.

Impact of IPCC assessment reports

The first assessment report of 1990 contributed significantly to the formation of UNFCCC. The subsequent reports have shaped the global debates on climate change. IPCC reports, particularly the AR4 report, have received enormous attention from the policy makers, industrialists, citizens and media. The IPCC Chair is invited to make a presentation at the beginning of all the UN Climate Convention meetings. Many world leaders quote IPCC findings routinely in all their speeches. UN Secretary General quotes the IPCC findings in all his writings and speeches. *Nature's* recent editorial said 'The IPCC's fourth assessment report had huge influence leading up to the climate conference in Copenhagen last year, but it was always clear that policy-makers were reluctant to commit to serious reductions in greenhouse-gas emissions'². One of the most heartening things for an IPCC author during the Copenhagen Convention was that every world leader or government negotiator knew and argued for the IPCC

finding on the need for Annex I (industrialized) countries to reduce emissions by 25–40% by 2020 over the 1990 level and 80–95% by 2050 over the 1990 levels⁶. The contentious Copenhagen Accord also acknowledged many of the IPCC findings such as the need for limiting the warming to below 2°C and the need for early peaking of the global GHG emissions. Even the unsubstantiated finding that crop yields in Africa would decline by about 50% by 2020 was at the heart of the demand for adaptation funding by the African delegates. The pinnacle of recognition for IPCC came with the award of the Nobel Prize in 2007. One of the most useful products of IPCC not often recognized is the GHG inventory guidelines, which is used by all the countries of the world in preparing and reporting of GHG inventories, a critical aspect in any effort to reduce GHG emissions. The authors, particularly from the developing world, benefit from the networking and collaboration established among the authors during the IPCC meetings, in pursuing their research.

Part II: Controversies: many myths and some realities

Climate change has always attracted controversy and negative publicity from many climate sceptics, vested interests and lobbies for over 15 years. When the AR2 was released in 1995, many climate change sceptics, particularly in the USA led by *The Wall Street Journal* launched a major offensive to discredit the findings of the IPCC on the issue of 'Discernable human influence and detection and attribution of causes of climate change'. The *Wall Street Journal* complained that alterations made in Chapter 8 of the 1995 IPCC report were to 'deceive policy makers and the public into believing that the scientific evidence shows human activities are causing global warming'. British newspapers such as *The Telegraph*, *Sunday Times* and *Observer* are also in the forefront of attempts to discredit the IPCC. The previous USA administration (2001–2009) did not recognize the IPCC findings at all. One of the main contentious issues continued to be the attribution of the observed warming to human induced GHG emissions. However, the release of IPCC AR4 WGI report in 2007 settled the issue once and for all in a robust way based on sound science. But IPCC was careful in its wording in AR4 'Most of the observed increase in global average temperature since the mid-20th century is very likely due to the observed increase in anthropogenic GHG concentration'. This is an improvement on the AR3 conclusion 'most of the observed warming over the last 50 years is likely to have been due to increase in GHG concentrations'. These two most important sentences from the two reports show how cautious IPCC is, and not exaggerating. As the reputation of the IPCC soared, the right-wing climate sceptics also became aggressive in the virulence of their attack on the climate

change phenomenon itself. The recent controversies surrounding the IPCC reports surfaced nearly two years after the release of the report in 2007, especially in the wake of the crucial Copenhagen Climate Convention. Some of the controversies that have affected the credibility of the IPCC are as follows.

Melting of Himalayan glaciers by 2035

The WGII chapter on Asian continent mentions 'Glaciers in the Himalaya are receding faster than in any other part of the world, and if the present rate continues, the likelihood of them disappearing by 2035 or perhaps sooner is very high if the earth keeps warming at the current rate'⁷. This gave an opportunity to the climate sceptics to discredit the IPCC as well as the science itself. IPCC agreed that it was not based on substantiated scientific evidence. It was sourced to a WWF report⁸ which in turn sourced it, from an interview published in the British science magazine *New Scientist*. It has to be noted that the main author of this chapter was an Indian expert. It is also surprising that this paragraph escaped the scrutiny of the multiple-layered review process, including that by the Indian scientists and the Indian government. Fortunately, this paragraph did not make it to the crucial SPM or synthesis report. Surely the authors of the chapter erred in judgement in including such a paragraph based on non-peer reviewed literature. There is no denying the fact that the glaciers are melting and will continue to recede at a faster rate in future due to global warming. Further, there is very limited peer-reviewed literature on the dynamics of the Himalayan glaciers. Though the Himalayan glaciers are so crucial for the hundreds of millions in India, very little scientific research and monitoring has been done, though there are many institutions which are dedicated to research on the Himalayas. If there was adequate scientific literature from the region, this kind of error would not have occurred.

Amazon forest loss

IPCC 2007 report⁹ states that up to '40% of Amazonian rainforests could react drastically to even slight reduction in precipitation'. Again this was based on a report prepared by the WWF¹⁰. However, results from a recent NASA-supported study¹¹ published in *Geophysical Research Letters (GRL)* based on satellite data showed that despite the worst drought of 2005, when all the lakes and rivers dried up in these forests, the researchers found no major changes in vegetation and forest cover, compared to non-drought years. However, scientists have clarified that the rainforests may have coped with short-term drought, but the long-term reductions in rainfall might have a very different effect. However, some of the newspapers went overboard and exaggerated the differences

between the IPCC conclusion and the new study. In fact, *The Sunday Telegraph* of London had a major story titled 'Now IPCC gets it wrong over Amazon disaster' and the newspaper further went on to misquote the IPCC report to state that 40% of the rainforests could be lost. It should be noted here that at the time of the preparation of the AR4 2007 report, the kind of studies published by GRL was not available. IPCC authors, in the absence of peer-reviewed literature particularly at the regional level, may have used the WWF report.

Decline in crop yield in North Africa

The WGII reported that 'by 2020, in some countries, yields from rain-fed agriculture could be reduced by up to 50%'¹². This was based on a study published by International Institute for Sustainable Development (IISD)¹³. This is criticized mainly because the rate of decrease predicted was considered as abnormal over such a short period for such a dramatic change. In the early part of its chapter, IPCC reported that this decrease could be due to both climate variability as well as climate change, but the issue got over-simplified later in the chapter indicating climate change as the only cause for the projected decrease in crop yields.

Extreme weather-related events

IPCC AR4 concluded that the world had 'suffered rapidly rising costs due to extreme weather related events since the 1990s'¹⁴. The report further stated 'once the data was normalized, a small statistically significant trend was found for an increase in annual catastrophe loss since 1970 of 2% per year'. However, IPCC authors seem to have only partially quoted the study¹⁵ that formed the basis of this conclusion and ignored the fact that the high losses, according to the same authors, were due to strong hurricane seasons in 2004–05. The study, when published in 2008, had a new caveat 'we find insufficient evidence to claim a statistical relationship between global temperature increase and catastrophe losses'. IPCC authors could have been careful in quoting such reports.

Fifty five per cent of the Netherlands below sea level

IPCC calculated¹⁶ that 55% of the Netherlands is below sea-level by adding the actual area below sea level (26%) with the area threatened by river flooding (29%). According to the Dutch Office for Environmental Planning, only 26% of the Netherlands is below sea level. IPCC was not wrong but could have explained the calculation procedure better. It was enough for *The Times of India* to declare 'IPCC got this wrong too'.

Reduction in mountain ice

IPCC report stated that the observed reductions in mountain ice in Andes, Alps and Africa were caused by global warming¹⁴. This information was based on an article published in a magazine for mountaineers, which was based on anecdotal evidence about changes observed by mountaineers during the climb. The other source was a Masters dissertation at the University of Berne, which quoted interviews with mountain guides in the Alps. IPCC authors could have been careful in quoting from such non-peer reviewed reports.

Methane controversy

IPCC prepares GHG inventory guidelines to assist countries to estimate and report GHG emissions and removals. IPCC GHG inventory guidelines published in 1996 provided methods, guidelines and default values for estimating the national GHG inventories, including methane emissions from rice production. The IPCC guidelines provide several methods available in the literature and also provides a three-tier approach, for estimating the inventory based on the countries' capacity to generate national database on the scale of activity and emission factors. According to IPCC guidelines, countries are free and even encouraged to use their own national emission factors. The US Environmental Protection Agency (USEPA) published a regional study on anthropogenic emissions of GHGs in 1990 (ref. 17). This study made an assessment of GHG emissions in 1990, based on the literature available at that time. Rice is produced using different methods of irrigation and cultivation practices in different countries and regions. It is true that the USEPA study may have used a higher emission factor for estimating methane emissions from rice production. IPCC never forced any country to use the default values provided in the USEPA study. The IPCC inventory guidelines are prepared on the basis of peer-reviewed literature. India reacted sharply stating that USEPA is trying to deliberately project higher methane emissions, which is not true. Further, it is quite possible that scientist who wrote that report in 1990 did not find any literature on methane emissions from different rice production systems in Asian countries including India. It is common in science to make assumptions, produce preliminary estimates and publish which are later improved or modified once new scientific data becomes available.

'Climate gate' and IPCC

'Climate gate' was one of the turning points in affecting the public opinion about climate science. This is traced to the prestigious Climate Research Unit (CRU) at the University of East Anglia in UK. The e-mails of scientists at

CRU were hacked and a large number of mails were downloaded before the Copenhagen Summit in November 2009, to discredit the climate science and IPCC findings by stating that the scientists manipulated and suppressed the climate data. There were questions regarding the raw data used in the models as well as the methods used. IPCC 2007¹⁸ quoted a study¹⁹ published in *Nature*, using temperature data from Chinese weather stations measuring the warming over the past half a century, concluded that the rising temperatures recorded in China were a result of the global climate change rather than the warming effects of expanding cities and further stated that 'any urban-related trend in global temperatures was small'. The history of the location of the weather stations was unclear and it turned out that out of the 84 weather stations in eastern China, one half were urban and the other half were rural. The authors however failed to provide the details of the locations of the weather stations. The leaked e-mails of CRU were supposed to have attempted to suppress information, particularly those pertaining to a series of measurements from Chinese weather stations. However, there is no denying the fact that the global climate has warmed in the past 50 years as shown by several other studies quoted in IPCC. The leaked e-mails were misinterpreted to imply that the climate scientists were trying to suppress and manipulate the data based on phrases such as 'hide the decline', and 'it would be nice to try to "contain" the putative medieval period'. The latter phrase was interpreted as 'delete, get rid of the medieval warming period' even though the authors had a different interpretation for words such as 'contain' which means to understand its dimensions. The Climate Gate happened just before the Copenhagen Climate Convention and was interpreted by many as an attempt to derail climate negotiations.

IPCC: need for change?*Multilayered review*

IPCC reports go through a multilevel review process involving four rounds; you cannot add any more layers, without delaying the process. Adding one more layer may not have avoided the Himalayan glacier type of mistake. For example, the IPCC chapters dealing with the Himalayan glacier issue, came to the Government of India twice, why did not the Indian government or the experts identify the Himalayan glacier melting issue? Only two years after the publication of the IPCC reports and a British newspaper report, the Indian government, media and scientists suddenly woke up and decided to attack the IPCC and its chairman. Earlier all IPCC reports were ignored by the Indian government and experts during the review process. Even though the Ministry of Environment and Forests (MoEF) tried to get the AR4 chapters reviewed,

the Indian experts either have not read the chapters including the one on the glacier or ignored or agreed with the controversial paragraph. If the government of India or experts had identified the glacier issue, surely it would not have found its way to the final version. Obviously, fault lies with the experts who wrote it and those who reviewed or ignored or agreed with the paragraph. IPCC as a body cannot be faulted. The IPCC secretariat does not have experts at the headquarters, who can check every sentence of the 3000 page reports. The IPCC chairman cannot be responsible for any errors in the report, since the chapters are written by a group of authors, and the report is subjected to intensive multilayered review process.

Transparency

Transparency is very important in science. The IPCC review process is probably more transparent than any journal process in science. All the chapters during the review process are accessible to everyone and all comments are considered and addressed. All the review comments and responses are easily accessible.

Literature from non-peer reviewed source

Majority of the controversies being debated are indeed due to sourcing of information from references from non-peer reviewed reports, or 'grey literature' such as those from WWF. IPCC has a process on how to treat such literature, but it has failed on a few occasions. The IPCC authors often refer to such literature only in the absence of peer-reviewed literature. IPCC should not ignore reports from many national and international agencies including the World Bank, UN bodies and well-known NGOs and find a mechanism to present any conclusions based on such literature differently. In fact, many international agencies also have a peer-review process for publishing their reports.

Lack of literature from developing countries or regions

IPCC cannot be blamed if there is limited or no literature from some of the developing country regions. In fact many global models do not depend on any regional data, whether GCMs or even dynamic global vegetation models. It is surprising that there is hardly any peer-reviewed literature on Himalayan glaciers. Given the importance of Himalayan glaciers, the Indian institutions should have studied them even in the absence of climate change concerns.

Non-suppression of facts or representing only one view

Barring exceptions over its long life, the IPCC process is more open and transparent than any international scien-

tific process. Each chapter and the comments are discussed in full lead authors (LA) meetings several times, including authors from developing countries. The discussions are open and never in my long association with IPCC have I noticed LAs being suppressed. The meetings are co-chaired by an expert each from developed and developing countries. No one associated with IPCC has ever complained that his or her views were suppressed; there could be exceptions which could be traced to some personal reason. Many may not know, IPCC provides a list of robust findings and uncertainties. IPCC has an agreed policy to address uncertainty and has never attempted to hide the uncertainty. It was only during the AR4 in 2007, IPCC made a conclusive statement that the evidence of human attribution of observed climate change was robust. From 1990 to 2007, IPCC never reported conclusively that the observed warming is due to human induced GHG emissions.

Inbreeding in climate science and journals

This is a common complaint by some authors whose papers are rejected by journals in their normal routine review process. Most important climate related science is published in journals such as *Nature*, *Science*, *GRL*, *Energy Policy*, *Global Environmental Modeling*, etc. There are new dedicated journals such as *Climatic Change*, *Climate Policy*, *Mitigation and Adaptation Strategy for Global Change*, *Journal of Climate*, *Climate Dynamics*, etc., and these are published by well-known publishers such as Springer, Elsevier, etc. and the editors are eminent scientists and economists and adopt an identical review and acceptance process. I am on the Editorial Board of four such international journals; never have the editorial board members ever considered any policy to restrict any papers that have views opposite to IPCC conclusions or against climate believers. In fact, the *GRL* recently published a study on Amazon which according to some is at variance with the IPCC conclusion on Amazon dieback. Where is inbreeding of climate science? Authors quoting their own papers and ignoring other papers is an unfounded myth. Anyone can open any chapter of the IPCC reports, you will find hundreds or even thousands of research papers being quoted. Probably the 7–10 LAs for a chapter do not account even 5% of the authors listed in the references. Thus it is a myth that the authors only quote themselves.

Voluntary nature of contributions

Some of the busiest scientists and economists provide their valuable time for IPCC. Developing country institutions, including India, do not provide any facilities for IPCC authors, not even special leave; some even apply for personal leave and go to IPCC meetings. Many scien-

tists work for IPCC, which is simply a review or synthesis, at the cost of their own research and consultancy projects in their institutions. Indian institutions do not recognize participation in IPCC meetings as official duty.

IPCC or climate scientists lobby?

There is also talk of lobby of climate scientists in funding agencies, journal editorial boards, etc. Where is the lobby, who funds such pro-IPCC or climate change lobby? Compare them with whom the climate scientists are up and against; the might of US government during the previous administration (during which the AR4 reports were prepared), mighty petroleum, automobile and airlines industry, coal and natural power generation companies, rich governments of petroleum producing companies. These companies and countries have trillions of dollars of annual business at stake in promoting increased use of fossil fuels. It is difficult to understand, how a few scientists can have a lobby to counter the might of the most powerful governments and giant corporations. In fact, there are rumours that during the eight years of the previous US administration (during the period of AR4), funding for climate science was cut, and any research group opposed to US government view was blacklisted. We should really appreciate the IPCC authors from US and other countries, who braved such threats and participated in the IPCC process. It is the most unbelievable thing to say that US government (the previous administration) or western governments are behind all AR4 IPCC findings. The US administration was opposed to IPCC as well as climate science. There are many websites dedicated to discredit the science of climate change and IPCC (e.g. <http://climatequotes.com/>, www.noconsensus.org, www.climate-Resistance.org). So if any lobby exists in the world, they are the most powerful and mightiest corporations and governments (of oil producing) which have all the power, money and might to counter and destroy the IPCC and climate science. If IPCC has survived, it is not because of lack of efforts of these lobbies, but the scientific validity of the reports and public faith.

Approval process of SPM

Anyone who participated in the approval process of AR4 reports would know that IPCC authors were forced on many occasions to delete or tone down any paragraph or sentence which were based on the main report and which highlighted that climate change is a serious threat or caused adverse impacts. There was a clear pattern in the approval process that one set of governments, who did not want paragraphs which highlighted the severity of adverse impacts. The approval process is a consensus-based approach, where every government has to approve every sentence and paragraph. It is a well-known fact that

many governments succeeded in diluting many of the paragraphs, barring a few exceptions. Every paragraph of SPM religiously refers to the section in the main report. There is not a single paragraph without reference to the main report. However, the final wording or language of the paragraphs is what is negotiated by the governments during the approval process.

Science academies to conduct independent review of IPCC

In response to the criticisms and controversies, the United Nations Secretary General and the Chairman of IPCC have set up an independent review by the prestigious Inter-Academy Council (IAC) of the IPCC's processes and procedures to further strengthen the quality of the panel's reports on climate change. IAC is the umbrella organization for various national academies of science from countries around the world. The review is expected to examine every aspect of how the IPCC reports are prepared, including the use of non-peer reviewed literature and the reflection of diverse viewpoints. The review will also examine institutional aspects, including management functions as well as the panel's procedures for communicating its findings to the public.

Conclusions

It is important to recognize that any stringent global agreement to reduce GHG emissions will adversely affect the business of giant petroleum, coal, natural gas, automobile and airlines corporations as well as countries depending on fossil fuel export. Despite the controversy and attempts by vested and most powerful and mighty lobbies at global level, IPCC process has survived and made significant contribution to global efforts to address climate change. Surely, there are opportunities to improve the scientific rigour or transparency of the process. But a few controversies and mistakes should not be used to sully the image of the IPCC and climate science. Probably there will be even more serious efforts in future to discredit the IPCC process so that governments need not do anything to address climate change and the giant companies and corporations can continue with their fossil fuel business.

IPCC should learn from the past and make the process stronger. IPCC should find a robust mechanism to treat the so called 'grey literature'. IPCC should increasingly present its findings at regional levels to enhance its utility for policy makers at national level. IPCC could also find a mechanism to sequence the preparation of WGI, WGII and WGIII reports. Surely more developing country experts need to participate and of course it should be based on the publication record and scientific contribution, except in a few cases where exceptions could be made to provide

representation to some regions. There is also a need to shorten the duration involved in the preparation of assessment reports from the current period of 5–6 years, since climate change science is progressing at very fast rate, requiring policy responses. The IPCC must establish a formal process for rapidly investigating and, when necessary, correcting such errors². The utility of the IPCC also depends on its direct relevance to climate policy decisions, and this sharp clarity of purpose requires that the IPCC avoids becoming entrained in many aspects of broader global change and sustainable development issues⁴.

Developing countries must also support more research on climate change in their own regions and get such literature into peer-reviewed scientific journals. The review process is adequate and rigorous and unparalleled in science, if any additional layer is added it will only delay the process. Any further tinkering of IPCC process based on negative or narrow consideration or casting aspirations on the authors will drive all genuine scientists away from IPCC. After all IPCC authors are human, prone to make errors in judgement or may even have their own biases. The team structure of the chapter authors, the multiple reviews by peers and governments, and the full and public documentation of this process largely eliminate personal views or biases in the science assessment. This role as an honest broker is now at risk, as the stakes are higher than ever before¹. IPCC is a unique, robust and monumental process in science, where scientific assessments provide valuable inputs to policy makers in addressing the challenge of global climate change, which requires a global response. Hopefully, an independent review by the IAC would provide suggestions for strengthening the functioning of IPCC.

1. Hulme, M., Zorita, E., Stocker, T. F., Price, J. and Christy, J. R., IPCC: cherish it, tweak it or scrap it? *Nature*, 2010, **463**, 730–732.
2. Climate of fear. *Nature*, 2010, **464**, 141.
3. Balaram, P., Climate science: drowned in the noise. *Curr. Sci.*, 2010, **98**, 463–464.
4. Solomon, S. and Manning, M., The IPCC must maintain its rigor. *Science*, 2008, **319**, 14.
5. IPCC 2007a, Climate Change 2007 – Synthesis Report, UNEP WMO, 2007.
6. Gupta, S. *et al.*, Policies, instruments and co-operative arrangements. In Climate Change 2007: Mitigation, Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (eds Metz, B. *et al.*), Cambridge University Press, Cambridge, UK, 2007, pp. 747–807.
7. Cruz, R. V. *et al.*, Asia, climate change 2007: impacts, adaptation and vulnerability. In Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on

- Climate Change (eds Parry, M. L. *et al.*), Cambridge University Press, Cambridge, UK, 2007, pp. 469–506.
8. WWF, An overview of glaciers, glacier retreat, and subsequent impacts in Nepal, India and China, World Wildlife Fund, Nepal Programme, 2005.
 9. Magrin, G., García, C. G., Choque, D. C., Giménez, A. R. M. J. C., Nagy, G. J., Nobre, C. and Villamizar, A., Latin America, climate change 2007: impacts, adaptation and vulnerability. In Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (eds Parry, M. L. *et al.*), Cambridge University Press, Cambridge, UK, 2007, pp. 581–615.
 10. Rowell, A. and Moore, P. F., Global assessment of forest fire, WWF/IUCN, Switzerland, 2007, p. 66; <http://data.iucn.org/dbtw-wpd/edocs/2000-047.pdf>
 11. Samanta, A. *et al.*, Amazon forests did not green-up during the 2005 drought. *Geophys. Res. Lett.*, 2010, **37**, L05401.
 12. Boko, M. *et al.*, Africa, climate change 2007: impacts, adaptation and vulnerability. In Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (eds Parry, M. L.), Cambridge University Press, Cambridge, UK, 2007, pp. 433–467.
 13. Agoumi, A., Vulnerability of North African countries to climatic changes; adaptation and implementation strategies for climate change, IISD, Knowledge Network, 2003, http://www.ckkn.net/pdf/north_africa.pdf
 14. Rosenzweig, C. *et al.*, Assessment of observed changes and responses in natural and managed systems. Climate change 2007: impacts, adaptation and vulnerability. In Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (eds Parry, M. L. *et al.*), Cambridge University Press, Cambridge, UK, 2007, pp. 79–131.
 15. MuirWood, R., Miller, S. and Boissonnade, A., The search for trends in global catastrophe losses. Workshop on climate change and disaster losses: understanding and attributing trends and projections, Hohenkammer, Munich, Final Workshop Report, 25–26 May 2006, pp. 188–194.
 16. Alcamo, J. *et al.*, Europe, climate change 2007: impacts, adaptation and vulnerability. In Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (eds Parry, M. L. *et al.*), Cambridge University Press, Cambridge, UK, 2007, pp. 541–580.
 17. Ahuja, D. R., Estimating regional anthropogenic emissions of greenhouse gases, US EPA Technical Series, Washington DC, 1990.
 18. Trenberth, K. E. *et al.*, Observations: surface and atmospheric climate change. In Climate Change 2007: the physical science basis, Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (eds Solomon, S. *et al.*), Cambridge University Press, Cambridge, UK, 2007.
 19. Jones, P. D., Groisman, P. Ya., Coughlan, M., Plummer, N., Wang, W.-C. and Karl, T. R., Assessment of urbanization effects in time series of surface air temperature over land. *Nature*, 1990, **347**, 169–172.

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