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Back to basics for the IPCC: applying lessons from AR6 to the Seventh Assessment Cycle



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The Intergovernmental Panel on Climate Change (IPCC) has been producing influential reports for over 35 years. As the IPCC's Seventh Assessment Report (AR7) cycle begins, we offer our perspective as former members of the IPCC Technical Support Units from Working Groups I, II & III, and the Synthesis Report on lessons learned during the Sixth Assessment Report (AR6) cycle. We identify three broad issues that, if addressed, could reinforce and sustain the IPCC in continuing its mission to comprehensively assess the scientific understanding of human-induced climate change. These are the imperative to ensure balanced representation, the importance of author recognition, and the need for improved institutional memory. Our recommendations include addressing skill and training needs, tackling barriers to participation particularly for Global South authors, and ensuring all contributors receive appropriate recognition for their efforts. We focus, in particular, on feasible incremental changes that could be implemented during AR7 without major changes to the underlying procedures that require approval by the 195 member governments that make up the IPCC.

Thirty years at the science-policy interface

For more than 35 years, the Intergovernmental Panel on Climate Change (IPCC) has been producing co-ordinated assessments of climate science, the social and economic impacts of climate change, and potential response strategies¹. In providing policymakers with a common, objective, and legitimate scientific basis for international dialogue, it has been influential in the establishment of the UN Framework Convention on Climate Change, the negotiation of the Kyoto Protocol, and the Paris Agreement^{2,3}. The IPCC has achieved this through a series of assessment cycles lasting 5-to-7 years and comprising Working Group assessments (WG I, II, III), methodology reports produced by the Task Force on National Greenhouse Gas Inventories (TFI), alongside targeted Special Reports and Technical Papers. (From the 3rd IPCC assessment cycle onwards, the IPCC Working Groups responsible have been: WG I—the physical science basis; WG II—Impacts, adaptation and vulnerability; WG III mitigation of climate change. The IPCC also includes the Task Force on National Greenhouse Gas Inventories. At the end of each cycle, the IPCC also produces a Synthesis Report that draws together the assessment cycle's major findings. The governance of the IPCC is determined by the 195 member governments that make up the

Panel (see Fig. 1). The Panel also elects the IPCC Bureau, decides what reports will be produced, agrees on their scope and outline, and approves each report's Summary for Policymakers (SPMs) online by line.

Over the last three decades, the IPCC has also become a popular subject of academic study as a boundary organisation that sits at a contested interface between science and policy⁴⁻⁸. This discourse has, amongst other issues, focused on: (i) how the IPCC 'demarcates science from politics'; (ii) the under-representation of Global South authors and practitioners; and, (iii) concerted attempts to undermine the credibility of IPCC assessment practices and authors, and of the knowledge that they produce⁹⁻¹².

Previous commentaries and debates have focused on how IPCC assessment procedures might be improved, how policy relevance can be maintained and strengthened, and how the IPCC itself has impacted scientific knowledge production^{13,14}. (Coite¹⁵ for example, argues that the work and structure of the Integrated Assessment Modelling community have been largely driven by the need to organise collective work on scenarios assessed by the IPCC). Critical perspectives have, at the same time, appraised the representation of academic disciplines, the dominance of particular author communities, the dominance of wealthy countries and

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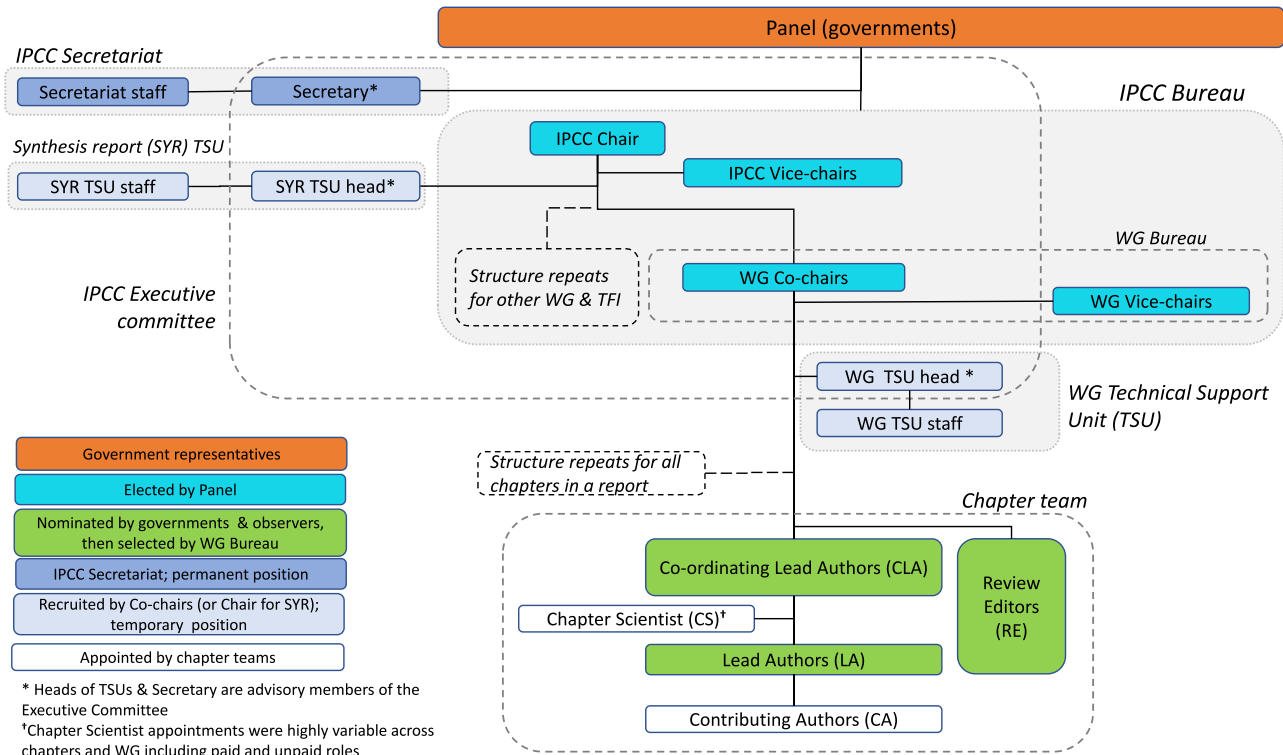


Fig. 1 | IPCC structure and governance. The governance structure of the IPCC is shown by illustrating a single Working Group (WG) and report chapter. The structure repeats with minor variations across WGs and chapters. Special Reports

can span multiple WG and the Taskforce for National Greenhouse Gas Inventories (TFI). (Original figure developed from the principles governing IPCC work^{26,27,41}).

institutions, the dominance of older and repeat participants, and the under-representation of early-career scientists, the Global South, practitioners, and women within the authorship and leadership of the IPCC^{3,16–21}. The IPCC’s perceived conservatism has also been debated, including the choice of assessment topics and the framing of IPCC assessments through a predominantly physical science and engineering lens rather than embracing perspectives such as economics, social sciences, Indigenous Knowledge, justice, equity, ethics and gender.^{22–24}

IPCC assessment cycles have been interspersed with periods of reflection as the Panel, authors, and observers debate what has been achieved and what might be done differently^{13,16,25}. At the time of writing, the AR7 cycle has recently commenced, and there is once again, an opportunity to take stock. This perspective is authored by former members of the AR6 Technical Support Units (TSUs) for Working Groups (WG) I, II, III and the Synthesis Report and draws on our collective experience. In our TSU role over the course of AR6, we co-ordinated the production of seven IPCC reports, informing and implementing the decisions of the WG Bureaus and contributing to the reports directly as editors and authors. We participated in every IPCC Panel, Bureau, and Executive Committee meeting and have benefited from countless conversations with authors and Bureau members sharing their triumphs and frustrations. As participants in AR6, we have also been shaped by our experiences, and our recommendations reflect this journey.

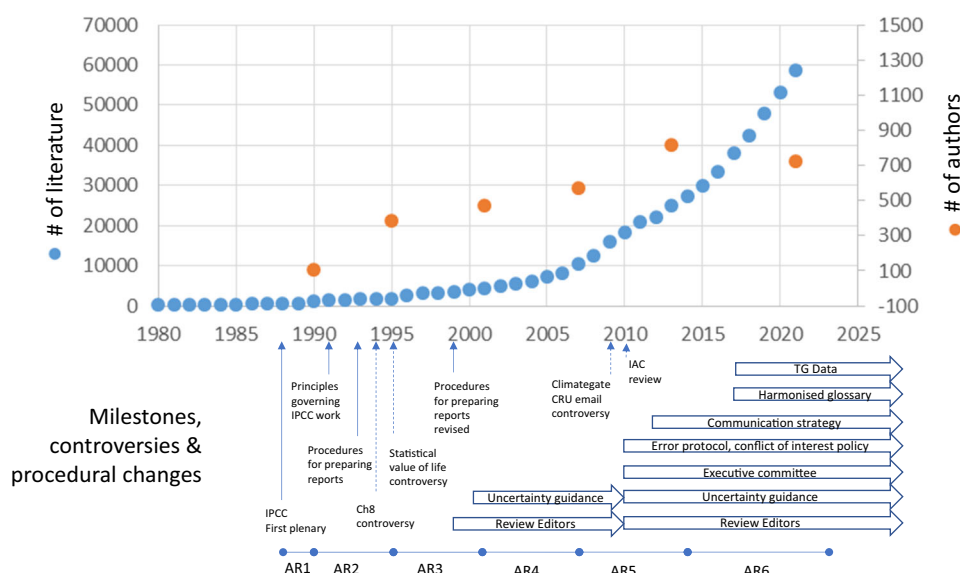
The remainder of this article is presented as follows. Parts 2–3 outline the governance of the IPCC, identifying some of the challenges that arose during AR6, and make the case that advocating for a series of incremental changes could improve how the IPCC functions and the experience of being an author. Parts 4–6 explore three issues intrinsic to the effective functioning of the IPCC: the imperative for balanced representation, the importance of author recognition, and the need for institutional memory. Drawing on this analysis, part 7 presents recommendations targeted to IPCC National Focal Points who represent the 195 governments of the Panel, the incoming AR7 IPCC Bureau, the IPCC Secretariat, and members of the AR7 TSUs.

Feasible steps towards a more effective and inclusive IPCC

The drafting and production of an IPCC report is an intense, demanding, and often inspiring process that involves hundreds of independent-minded volunteer authors striving to effectively communicate the state of knowledge based on their critical examination of multiple lines of evidence and their limits. The IPCC as an organisation, however, is complex, slow to change, and encompasses a bewildering array of interacting principles, processes, and precedents.

The IPCC’s current governance structure, structure (illustrated in Fig. 1), is complex, and in combination with the IPCC’s exacting requirements for report production and the limited capacity of the scientific community, this places hard limits on the number of reports that can be produced in a cycle. The ultimate decision-making authority is the Panel, and all major decisions of the IPCC are taken by the Panel in plenary^{5,10}. The Panel elects the Bureau members for a single assessment cycle. Their mandate is to advise the Panel and ‘uphold and implement the principles and procedures of the IPCC’²⁶. The IPCC Executive Committee is mandated to address ‘urgent issues related to IPCC Products and Programme of Work’²⁷ and includes only the Chair, IPCC Vice-Chairs and the WG Co-chairs and TFI, with the Heads of TSU and IPCC Secretary as advisory members. (Over the course of AR6 some WG Vice-Chairs expressed frustration that their exclusion from the Executive Committee impeded their ability to carry out their mandated role ‘to provide guidance to the Panel on the scientific and technical aspects of its work, and to advise on related management and strategic issues’). Each WG is led by developed and developing country Co-Chairs. The host country of one of the Co-Chairs (in practice, the government of the developed-country Co-Chair) hosts and funds the TSU for that Working Group. In AR6, some TSU staff were co-located with the developing country Co-Chair of each WG (some of whom were funded directly by the developing country). The Secretariat supports the Panel, Chair and WG Bureau individually and corporately. The only permanent staff positions within the IPCC are within the Secretariat. Everyone else is either a

Fig. 2 | IPCC Timeline: assessment cycles, the volume of literature, key events and procedural change. Web of Science (<https://www.webofscience.com>) search results of the number of papers tagged with ‘climate change’ (blue dots) from 1980 until 2021 compared with the number of selected authors in each of the six IPCC cycles (combined totals for all three working groups). IPCC Milestones, Controversies and Procedures changes from DePryck et al.⁵. IAC review = InterAcademy Council review of IPCC processes and procedures³¹.



volunteer or on a short-term contract. The Secretariat’s primary responsibility is to support the Panel; during AR6, it had limited engagement in, or practical knowledge of, how the WGs functioned.

The Working Groups operate essentially as ~7-year franchises. Each cycle begins with the dissolution of the WG from the previous cycle, and the election by the Panel of a new Chair, WG Bureau and Co-Chairs. Prospective Bureau members (including the Co-Chairs) are nominated by their governments and, in almost all cases, have prior experience of the IPCC, for example, as authors or having served as a Bureau Member in previous cycles. An in-depth understanding of the tasks undertaken within a WG, however, may be more limited. The new Co-Chairs set up the TSU in the first year of operation and started the process of scoping the new reports requested by the Panel, selecting authors, and beginning the assessment cycle anew. Historically, there has been very limited continuity in TSU staff between cycles.

Decision-making processes within the IPCC are set out in the Principles Governing IPCC Work approved by the Panel. These Principles, however, are not exhaustive and leave room for interpretation and debate. For example, there may be disagreement on both goals and the processes by which they are best achieved. The IPCC’s own processes are not always well understood by its members, such that pragmatic interventions of necessity, the residue of learning from past experience, and trial-and-error processes can dominate. The amount of effort participants can devote to resolving problems can also be variable given the multiple demands on their time.

Effecting change within such a decision-making context requires attention to the strategic effect of how and when choices and problems are introduced, as well as to the participation and energy of participants²⁸. The recommendations we provide at the end of this article are therefore presented as a sequence of incremental changes as our experience suggests these can more rapidly effect positive change than more radical proposals that require 195 governments to reach a consensus and most often result in the status quo²⁹. Ultimately, however, both incremental and radical approaches to change can be complementary and necessary.

Taking stock at the end of AR6 and strengthening the capacity to deliver

The IPCC’s Sixth Assessment Report (AR6) cycle was the longest and busiest assessment cycle to date. In a document submitted to the IPCC in September 2022, the Co-Chairs of Working Groups I, II & III shared some of the lessons learned during their stewardship of the three Special Reports and three WG reports produced during AR6. Key aspects that they, and the WG Heads of TSU, identified as having added to pressures on authors, Co-

Chairs, Bureau members, and TSUs include: (i) the rapidly growing volume of scientific literature relevant to the assessment (see Fig. 2); (ii) the increasing number of comments on draft reports by experts and governments; (iii) growing demands for external engagement as interest in the IPCC reports increases; (iv) full implementation of procedures for handling errors, conflicts of interest, data transparency, etc.; (v) demand for increased levels of coordination across IPCC products; (vi) working hours and days that go well beyond the limits of physical health and mental well-being; (vii) the mental/emotional toll on Co-Chairs and TSU staff of managing author expectations and experiences regarding inclusion, conduct, and levels of workload over multiple years without any human resources support or additional financial support.

In AR6, authors committed time well beyond initial expectations with implications for family life and professional obligations outside IPCC. This differentially affected women, early-career academics, young parents, and authors from the Global South. Extended processes resulting from the COVID-19 pandemic and a delay in the delivery of the Synthesis Report also led to a drop-off in active participation as the cycle progressed³⁰. The additional pressures from the COVID-19 pandemic, the shift to remote/online meetings and the lack of face-to-face interaction exacerbated many of these issues. The Co-Chairs report warns that ‘a significant number of authors would not consider, or would not recommend, future participation in IPCC as a result of their experiences in AR6’³⁰.

Although exhaustion at the end of an IPCC cycle is not new¹⁴, authors and Bureau members are volunteers, and the risk of the global scientific community becoming demotivated from engaging with the IPCC should be taken seriously. If the learning curve for new authors is too steep, the demands of the assessment process too arduous, and the benefits of participating inadequate, the core mission of the IPCC is to ‘provide governments at all levels with scientific information that they can use to develop climate policies’ could be compromised.

There are, however, considerable grounds for optimism. Over the past 35 years, the IPCC has shown itself capable of innovation and change. Although change, when it has occurred, has most often been in response to crises³¹, and has resulted in increased proceduralisation of the writing and reviewing process (see Fig. 2). The cyclical nature of the IPCC also offers the potential for renewal and rejuvenation. Each cycle starts with a new team enthusiastic to make their mark. Incentives for ‘maintaining the status quo’ are also reduced compared to some UN organisations because IPCC participants are unpaid and do not hold permanent positions⁹.

Irrespective of the leadership in any single cycle, the IPCC provides a forum for governments and the scientific community to discuss and shape

assessment activities and this builds in responsiveness to policymakers' needs. The IPCC co-production process also generates a sense of ownership by both the scientific community and governments³².

Representation is a prerequisite to legitimacy

IPCC reports are considered authoritative, in large part, due to the rigorous process by which they are written and the composition of the author teams^{20,33,34}. The importance of representation is captured by the words of Bert Bolin after he was asked to become the first chair of the IPCC:

*"Right now, many countries, especially developing countries, simply do not trust assessments in which their scientists and policymakers have not participated. Don't you think global credibility demands global representation?"*⁹

This sentiment remains as true now as it was 35 years ago, but the IPCC has also made substantial progress in increasing representation. In 1993, the procedures of the IPCC were amended to state that every IPCC chapter should contain 'at least one' developing country lead author and financial support for 'at least one' developing country lead author. The current IPCC principles (updated following the 2010 review by the InterAcademy Council³¹ following the Climategate CRU email controversy (see Fig. 2)) state that the Working Group Bureau should ensure 'appropriate representation of experts from developing and developed countries and countries with economies in transition' and that 'there should be at least one and normally two or more [authors] from developing countries'³⁴. IPCC procedures also mandate that author teams should 'aim to reflect a mixture of experts with and without previous experience in IPCC; and gender balance.' Current precedent and practice, however, go well beyond this with an aspiration of 50/50 developed/developing country representation, including the provision of Trust Fund travel support for developing country authors. Indeed, for the AR6 Special Report on Climate Change and Land, developing country authors, were for the first time a majority. While a gender imbalance persisted during AR6, progress was nevertheless made with the Panel agreeing on a 'Gender Policy and Implementation Plan' to develop a framework of goals and actions to improve gender balance and address gender-related issues within the IPCC³⁵. The AR7 WG Bureau elected in July 2023 includes 14 (41%) women. This is greater than the 8 (25%) women elected to the AR6 Bureau, however, the representation of women in the AR7 leadership roles that constitute the Executive Committee has decreased compared to AR6.

The IPCC's principles were not updated during the AR6 cycle. At the IPCC's 52nd Session in Paris 2020, the Panel invited the Secretariat to prepare a summary of Member States views on the 'review of the principles governing IPCC work' (Decision IPCC-LII-7) for consideration during the 53rd Session, however, this was dropped from the agenda of the 53rd session as a consequence of the Covid-19 pandemic necessitating a virtual meeting with a reduced agenda. A review of the IPCC's principles is anticipated in AR7.

Building a balanced and representative author team based on the nominations from member governments, IPCC observer organisations and Bureau members, is one of the primary responsibilities of the WG Bureau and requires numerous judgement calls. The IPCC criteria for a balanced team include scientific expertise, geographical and developing country representation, a balance of new and experienced authors, and gender³⁴. The selection, however, is not straightforward. Some countries do not nominate any women, others do not nominate any early-career researchers. Many countries do not nominate anyone at all. Individuals with a prior record of non-contribution may be re-nominated, and Bureau members may be unaware of the prior non-contribution, or may prioritise the need to ensure regional and overall balance.

The scientific community is also highly mobile. It may seem common sense that an author who moves country part way through a cycle is still counted as representing their country of origin, but should authors born in the Global North but living and working in the Global South be counted as representing the Global North or South? Should someone born in the Global South who has lived and worked in the Global North for many years be said

to represent their country of birth? These are some of the sensitive geopolitical questions the WG Bureau must address²¹.

The desire to increase the legitimacy of IPCC reports by ensuring balanced representation and the necessity to ensure those selected have the capacity, resources, and motivation to contribute effectively go hand in hand⁸. Experience in AR6 shows that decisions seeking to ensure a balanced team can be slow-to-make and contentious, particularly when the issues of representation (regional, gender, developing country, previous experience), expertise, and capacity coincide. Expanding and deepening the pool of nominations from developing countries, of women, and of early-career researchers aligns with the IPCC's core mission but requires time, resources, and the active engagement of Bureau members, Focal Points, and Observer Organisations.

Overcoming barriers to participation and recognition

Participation in the IPCC and recognition as an author has considerable value for individuals in that it carries prestige that can directly benefit the careers of those involved. Working together as a multidisciplinary team across regions, languages and countries in pursuit of a shared goal can also be a social, creative, and scientific adventure. Authors volunteer because the goal of producing an impactful report is intrinsically worthwhile and, despite what one commentator describes as the 'crushing rounds of review and layers of oversight'¹⁶, it can also be a fun and rewarding experience.

Many IPCC authors and Bureau members in AR6, however, faced barriers to participating fully. Constraints included the strains of working in a non-native language, working from particular time zones, and the inability within some countries to access collaborative working tools such as Google Docs. Biases, such as the perceived value of disciplinary or regionally focused expertise within an author team or the impact of particular individuals dominating discussions, could also be insidious barriers to participation and difficult to overcome. Here, the skill of the chapter Co-ordinating Lead Authors in facilitating a culturally and disciplinary diverse team can make a big difference to the effective functioning of the chapter team, as could the training and support they received. (In AR6, WG I provided specific training on inclusive and participatory practices with some success, but the playing field is far from level³⁶). For some Global South authors, access to electricity, internet connectivity, and the literature could not always be taken for granted. A particular problem faced by authors and Bureau Members whose travel was funded by the IPCC Trust Fund was the imposition of painfully long and arduous travel itineraries, in some cases making participation in meetings impossible.

In AR6, provision was made for Global South authors to access the literature via the UNEP Library facility. This provision was ineffective as the range of available literature was extremely limited compared to the access available within many Global North institutes. Moreover, barriers to access were far too high. Authors could not run their own literature searches and were required to send search requests to librarians, resulting in time delays. The UNEP Library themselves did not have access to all required papers resulting in Global South authors being reliant on the generosity of Global North co-authors to send them texts to assess. This inability to access high-quality climate literature was a significant barrier to Global South researchers' ability to participate.

Over a long assessment cycle, there are many good reasons why an individual may not be able to contribute as fully as they had intended. Other work commitments, illness, family events, and war, may all play their part, as may disparities in the capacity and willingness of authors' home institutions to make time available, for example, by relieving them of other duties (a particular problem for Global South authors). There is also a need for a balance of skills amongst contributors to IPCC reports. Some authors may be less adept at contributing text but may be exceptionally skillful in defending the report to governments or in communicating the outcomes. Flexibility and sensitivity in dealing with such issues is essential. The non-contribution of a minority of authors once selected and of Bureau members once elected, however, can be a considerable source of frustration for those

from all corners of the globe who go above and beyond to ensure the final report is robust, credible and authoritative.

Decisions on whether to include additional experts in the role of Lead Author or to ask an author to step down are the purview of the relevant WGs and TFI Bureau. These decisions also require consideration of the selection criteria defined by the procedures, including geographic representation and gender balance, but are invariably difficult. In AR6, all the WG adopted a staged process whereby non-contributing authors were asked to increase their contribution or, if no resolution could be found, asked to withdraw. In a process with only four author meetings and limited review periods, this stepped approach was often timed out before reaching a resolution. Some WG Bureau members felt such decisions were the sole responsibility of the WG Bureau; others were wary of making changes to chapter teams that might result in governments raising concerns of imbalance and representation. The practical consequence was that once selected, recognition as an author was seldom revoked, to the disadvantage of others within the chapter team as well as the many aspiring authors from all regions that would have welcomed the opportunity to participate. While the IPCC principles allow for the substitution of Bureau members 'unable to perform the functions of that office' while retaining regional balance, no non-contributing Bureau members were replaced during AR6.

Challenges also arose in relation to appropriately acknowledging substantive contributions to the assessments after these contributions had been invited and received. This was a particular issue for early-career researchers who may have initially volunteered as Chapter Scientists or as Contributing Authors but who ended up making a scientific contribution to chapters, and products such as the Summaries for Policy Makers, at an equivalent level as Lead Authors yet were generally excluded from the list of authors and thus excluded from the report citation. During the production of the Special and WG reports, there were many contrasting and divergent views expressed about how contribution and authorship should be acknowledged. Examples include: (i) that all substantive contributions should be acknowledged – in line with the basic principles of research ethics; (ii) that junior or salaried contributors (including some Chapter Scientists and some TSU members) should not expect to be acknowledged as authors; and, (iii) that the ability of some Co-ordinating Lead Authors (CLA) or Lead Authors (LA) to fund a research assistant should not be a back door to lead authorship for that individual, as not everyone could afford a research assistant. The consequence was that decisions were often slow and occasionally inconsistent, to the distress and frustration of those concerned³⁷. The most severe disagreements contributed to the delayed production timeline for the IPCC Synthesis Report.

The IPCC principles are explicit that 'solicited' and 'unsolicited' contributions to reports 'are encouraged' and that all contributions 'will be acknowledged'³⁴. Following the initial selection of authors by the relevant WG Bureau, the specifics of how recognition is given has primarily been dependent on the participants role and past practice. For example, inclusion in the citation is specific to CLAs and LAs, inclusion as a Contributing Author is determined by the individual chapter author team, and inclusion as a Drafting Author of the Summary for Policymakers is determined by the relevant WG Bureau. Looking back over six cycles, and across the three Working Groups and Synthesis Report, the IPCC has precedent both for and against many such decisions. For instance, precedent exists for including Contributing Authors on the title page of SPMs and Technical Summaries as 'drafting authors'. Precedent also exists for elevating Contributing Authors to the role of Lead Author on the basis of their scientific contribution (and including them in the citation), for elevating Lead Authors to the role of Co-ordinating Lead Author, and for Chapter Scientists and Review Editors stepping down and becoming Lead Authors. At the same time, precedent exists for refusing all such changes.

During the writing process, interpersonal difficulties (for instance concerns about implicit bias) sometimes occurred within writing teams. One of the innovations in AR6 was the collaboration of the WGs and the Secretariat to develop a code of conduct³⁸. The code was based on UN best practice but lacked a mechanism for responding to formal infractions.

Developing an effective code of conduct and a robust institutional process to address complaints in a context in which most participants are volunteers is far from straightforward. The code was nonetheless positively received by authors, and its implementation was welcomed by the IPCC, demonstrating a willingness to confront and address issues openly and transparently. Work to strengthen the code of conduct and its implementation across the IPCC as a whole is being taken forward by the IPCC Gender Action Team (newly established during AR6 as part of the implementation of the Gender Policy³⁹) and will continue in AR7.

Building institutional memory and resilience

At the end of each cycle, the IPCC suffers a loss of institutional memory as those who participated in it disperse. At the start of the AR6 cycle, a similar hiatus in institutional memory was a mixed blessing. It allowed the WG Bureau the flexibility to respond to immediate circumstances with a fresh perspective, but, as the implementation of the IPCC policies and procedures were debated and examples of past precedents considered, it also extended decision-making processes that might otherwise have been straightforward.

When developing and discussing plans to conduct the AR6 WG and Special Report assessments, the IPCC principles³⁴ underpinned the assessment approach, but in practice, many decisions were guided by precedent. Over six cycles, each of the Working Groups has also developed its own culture and working practices which, at times, presented challenges to joint working across the three WGs. Much of the practical institutional memory also resided with those authors who participated in previous cycles and was only fully accessible to newcomers once the cycle of lead author meetings was up and running.

For newcomers to the IPCC, including some Bureau, TSU, authors, and Focal Points, there is no formal induction or training beyond the IPCC's principles and procedures and formal guidance on topics such as the use of 'calibrated uncertainty language'. When the IPCC franchise renews following the election of a new Bureau, many informal conversations and handovers take place, but they are reliant on the generosity of former post-holders to volunteer support after the cycle has ended and they have moved on to other positions. The incoming Bureau and TSU may also choose to disregard any recommendations they receive.

One of the consequences of this limited institutional memory is that cycles are slow to start as Bureau and TSU members new to the IPCC find their feet and discover their roles and responsibilities. The flexibility to choose between past precedents opens up the opportunity to act in the best interests of authors and to be responsive to governments, but it also provides no impediment to inconsistent decisions.

Ensuring a bright future for IPCC assessments

The following recommendations come from our collective experience of participating in the Technical Support Units of the WGs & SYR during the AR6 cycle. They reflect a shared view that targeted incremental change and innovation in how the IPCC conducts assessment can both better meet the needs of the policy community and better support the hundreds of scientists who devote time and energy to the IPCC. We expect such back-to-basics improvements can be valuable even if the Panel decides to pursue a more radical reform agenda in the future⁴⁰. The primary target audience for these recommendations is the 195 governments that make up the IPCC, the newly elected AR7 Bureau, the IPCC Secretariat, and members of the AR7 TSUs. For the next 7 years, these individuals will be the custodians of the IPCC, and the decisions they make will determine the IPCC's effectiveness, relevance, and survival.

Strengthening the capacity to deliver

- In AR6, producing three WG reports, three Special Reports, a Methodology Report, and a Synthesis Report pushed the organisation and authors to breaking point. The Panel and Bureau should give greater consideration to the realistic number of products that may be produced

- in an assessment cycle, particularly where overlaps in processes such as writing, review, and approval periods may occur.
- The Panel should recognise that adequate time must be allocated to authors to draft reports. The procedures currently state that governments require two 8-week periods to review reports, and taken together with the time required for scoping, compilation, and administration, this sets hard limits on how quickly a report can be produced if the writing itself is not to be compromised.
 - The election of the WG Bureau (including Co-Chairs) prior to deciding the topic of the reports to be scoped and written reduces the scope for flexibility in delivery. While the three-WG structure of IPCC remains unchanged in AR7, other structures may better meet policymakers' needs over the longer term. Defaulting to a three-WG structure favours the production of lengthy WG assessments, which comes with the risk that policy relevance may diminish compared to more focused Special Reports. A process for selecting priority assessment topics before Bureau elections could help address this. For AR8, this would require a Panel decision well before the end of the AR7 cycle.
 - The Secretariat should contract experts to investigate how the use of technology could streamline IPCC assessment procedures and reduce authors' overburden. This might consider, for example:
 - The use of professional collaborative software platforms (accessible to all authors) for collaborative drafting and reviewing thereby removing the need for unwieldy and inefficient static text documents and spreadsheets. The use of open repositories such as Zenodo to archive IPCC documents and ensure effective version control by allocating digital object identifiers.
 - The adoption of efficient tools and practices for virtual meetings, recognising that the virtual format brings both benefits and barriers to participation.
 - The use of Artificial Intelligence applications to support authors' work with the growing number and multi-disciplinary nature of the literature base, as well as non-English language literature.

Increasing representation and tackling barriers to participation

- Significant investment is required by multiple actors to expand and deepen the pool of nominations from developing countries, of women, and of early-career researchers.
- WG Co-chairs have a key role in designing the author selection process for their WG and should be prepared to solicit additional nominations if required.
- The Panel should consider mechanisms to support the Focal Points and Observer Organisations in identifying strong candidates from under-represented groups and regions for both Bureau and author nominations. Early-career researchers, in particular, bring dynamism, fresh perspectives, and creativity. This could include soliciting suggestions from former IPCC authors and other epistemic communities. This would need support from the Secretariat so that IPCC communications and outreach activities could further promote the opportunities for participation, build awareness of what participating in the assessment entails, and lead to a more diverse pool of candidates to participate.
- The Panel should consider revising the principles and procedures to ensure that all substantive scientific contributions are appropriately acknowledged following scientific best practice. The WG Bureau could take this up as a formal agenda item and come to an agreement that offers clarity on what constitutes authorship. Following this, IPCC principles and procedures could be revised to:
 - include a clear statement on the ethics of authorship that is consistently adopted;
 - explicitly include early-career researchers in the criteria for a balanced team;
 - set the expectation that those unable to contribute will be asked to step down; and,
 - formally define the role of Chapter Scientist.
- The Secretariat should ensure that authors without access to literature via their institutions are provided with the breadth of access—and the barrier-free access—they require through a mechanism that is fit for purpose (i.e., where authors may directly search and access all the available literature). This may require co-ordinated action by the Secretariat and Working Groups, with provision of funding by the Panel.
- The Secretariat should set up mechanisms to work with developing country institutions to explore what enabling conditions would allow their authors to make dedicated time available to participate in the IPCC.
- Developing country authors and chapter scientists require flexible and targeted support. When developing travel itineraries, efficiency, welfare, and flexibility should be prioritised. Trust fund support should be extended to include IT equipment, and software where required. In many instances, a year's broadband subscription and software to enable effective virtual participation could cost less than a single flight.
- In-person meetings are vital in building effective working relationships and cannot easily be substituted. Virtual working removes some barriers to participation and creates new ones. The decision on the modalities used and how to ensure an inclusive working environment requires careful monitoring by future Bureau, TSUs and the Secretariat.
- The IPCC Secretariat, working closely with the TSUs, should implement the code of conduct without fear or favour. A pathway for responding to formal concerns raised when the code of conduct is not respected should be finalised by the Gender Action Team and consistently followed.

Building institutional memory and resilience

- Recruitment to the Secretariat needs to better reflect the organisational and scientific needs of the IPCC, including the need for institutional memory. For all Secretariat positions, the Panel should request that both a developed and developing country-elected Bureau Member serve on the recruitment panel to strengthen the link and relevance for WGs of the Secretariat's team - including specifying the role, screening CVs, conducting interviews and deciding the appointment.
- The Panel should identify a mechanism to support the development of induction and training material accessible to Focal Points, Bureau members, TSU, Co-ordinating Lead Authors, and Lead Authors. This could:
 - include training on how the IPCC assessment process works, lessons learned, code of conduct, inclusive practices, facilitation, cultural awareness and unconscious bias; and,
 - encourage countries to nominate women, early-career researchers, practitioners and experts from Indigenous communities.
- Resourcing the capture of lessons learned over successive cycles, and the handover from the Bureau and TSUs to in-coming IPCC teams could save duplicated effort and time and strengthen the IPCC's legacy.
- The Panel and Bureau should recognise that while new and changed procedures may be necessary, increased proceduralisation is not a panacea as it places additional burdens on the assessment process and authors and can reduce flexibility. In this context, the IPCC should be open to learning from younger global assessment processes, including the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), the Global Environment Outlook (GEO), etc. by adopting constructive, dynamic, and innovative practices where they can be found.

Providing policymakers with robust and legitimate assessments of the best available science remains the core mission of the IPCC. We believe the incremental improvements suggested here are feasible to implement within the existing IPCC governance frameworks, and during the AR7 cycle. When taken together, they would help strengthen the IPCC's credibility and impact and better support new and existing authors. Implementing these recommendations does not preclude more radical reconfigurations of how

the IPCC conducts its work, but focusing on the basics of supporting authors and building processes that can deliver credible and legitimate insight will strengthen the IPCC, no matter what direction it takes in the future.

Data availability

The data are available from the corresponding author on reasonable request.

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Author contributions

R.S., M.T., M.P. and S.C. contributed to the study conception and design. The first draft of the manuscript was written by R.S. Figure 1 was developed by R.S. and M.T. Figure 2 was developed by S.C. and R.S. All authors contributed substantial insights based on their experience as members of the IPCC Technical Support Units for Working Groups I, II, III and the Synthesis Report. All authors critically reviewed the draft and approved the final manuscript.

Competing interests

The authors declare no competing interests.

Additional information

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