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Climate action post-Paris: how can the IPCC stay relevant?

The Intergovernmental Panel on Climate Change (IPCC) has been a crucial facilitator of climate change research and governance. After its sixth assessment cycle, the organization is at a critical juncture. The amount of climate science has grown tremendously over the past three decades, but so has global emissions of greenhouse gases. If the world is to reach the objectives implied by the Paris Agreement, climate action must accelerate on an unprecedented scale and pace, across widely differing contexts. Scientific knowledge will play a key role in this endeavour. Everyone who produces or relies on climate knowledge needs to wrestle with this pivotal question: *How can IPCC processes and outcomes be reformed to produce knowledge that is more relevant for climate action?* The organizational and resource constraints of the IPCC must be considered when searching for answers. This is an introduction to a special collection of research articles, reviews and perspectives dealing with this question from many different angles. In this introduction, we present four possible reform agendas for the IPCC in the form of ideal types, all with their advantages and disadvantages. This introduction does not advocate a certain set of reforms but rather attempts to spur discussions and reflections on the IPCC and its future.

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INTRODUCTION

The Intergovernmental Panel on Climate Change (IPCC) has played a crucial role in putting climate change on the agenda and shaping how climate change is perceived. It has helped catalyse the emergence of strong climate research communities, as well as international climate politics, manifested through the landmark Paris Agreement[1]. Policy relevance has been at the core of the IPCC mandate ever since it was established. However, both climate science and climate governance have evolved significantly since the establishment of the IPCC in 1988 and the United Nations Framework Convention on Climate Change (UNFCCC) in 1992. The IPCC was set up to better understand climate change as a phenomenon and facilitate development of a global policy response, but climate change and climate action now span all levels of governance, actors and spheres of society. Consequently, the IPCC faces several profound challenges at this stage in its evolution.

In this introduction to a special collection of papers, we present new conceptualizations that can help us deal with the following question: *How can IPCC processes and outcomes be reformed to produce knowledge that is more relevant for climate action*, considering organizational and resource constraints? We will discuss this question against the backdrop of the policy landscape in which the IPCC operates, how the IPCC works and is governed, and the opportunity for the IPCC to manoeuvre. We aim to facilitate a realistic exchange of ideas, and thus we pay attention to the organizational and resource constraints that limit the available reform options for the IPCC.

To meet the objectives implied by the Paris Agreement, there is an unprecedented need for climate action. Here, climate action is understood as the 'all activities and behaviour of individuals, groups, and organizations at various levels of spatial, temporal and institutional scale deliberately directed at preventing or reducing climate-related damages to society through mitigation and adaption actions'[2]. At the same time, the UNFCCC is tasked with facilitating the 'ratcheting' of ambition, and as part of this, the IPCC is expected to be relevant to the Paris Agreement's Global Stocktake running in a five-year cycle.

With a broad interest in climate policy across many levels, we have entered an era of polycentric climate governance[3]. Nationally Determined Contributions (NDCs) constitute the main building blocks of the Paris Agreement, and this shift to the national level poses new challenges to the IPCC in terms of target audiences and policy relevance. The IPCC has traditionally steered clear of assessing national policies, and shifting the focus of the IPCC from diagnosing the global problem to being relevant to country-level solutions may challenge the IPCC's mandate and practices. Nearly all countries are signatories to the UNFCCC and the Paris Agreement, and over the past decade, the volume of domestic climate policies has multiplied[4]. By 2023, close to 90% of global GHG emissions were covered by national net-zero targets[5]. Although many of these targets are ambiguously defined when combined with progress on clean technologies[6], it gives hope that the temperature goals of the Paris Agreement can be reached[7,8]. However, despite this progress, global GHG emissions continue to rise. The IPCC is now initiating its seventh assessment cycle (with leadership elections in July 2023), and based on historical precedence, the seventh assessment would be expected to finish sometime around 2030, the year where global GHG emissions should have reduced around 50% from today and the year that 1.5 °C may be crossed[9]. Given this new context, how useful would the seventh assessment cycle be if it were only a marginal deviation from the previous? The need to diagnose the climate problem and motivate climate action is fading, while the need for knowledge of how to adapt and mitigate is urgent.

Climate science has expanded tremendously in volume, as well as in disciplinary and issue-related diversity[10]. Climate science is no longer primarily a physical science issue[11]. It encompasses most scientific disciplines and an ever-growing number of research topics. The literature is vast, and many scientific discussions run in parallel with limited dialogue across subthemes. Even though our understanding of the societal changes required to cope with climate change has expanded vastly over the past few years, we still have limited knowledge about how to adapt to and mitigate climate change. The changing nature of climate science and new knowledge needs puts increasing pressure on all actors and processes in the IPCC system[11]. This goes for all IPCC authors, the staff in the technical support units (TSUs) for the IPCC working groups, the IPCC Bureau (which provides guidance on the scientific and technical aspects of the IPCC's work) as well as the national focal points (the national focal points nominate IPCC authors, facilitate reviews in their respective countries and

represent their country in IPCC processes). The resources of the IPCC are committed by governments, and it needs to find ways of operating within its constraints.

There is a lack of dialogue between those who study the IPCC, those who are involved in the IPCC in different capacities and those who read and rely on the reports, such as policymakers and other stakeholders. In this special collection, we aim to bring these groups together. We gather research as well as perspective pieces from IPCC insiders as well as outsiders specializing in researching the IPCC and other scientific bodies. We believe that this dialogue could be constructive and fruitful when considering and building on insights from different schools of thought that explore the relationship between science, policy and societal developments, such as the philosophy of science, science and technology studies (STS), and parts of political science[12]. These avenues of research have facilitated a deeper understanding of the relationships between science, politics and policy, including the roles of the IPCC and the challenges it faces[13].

We discuss IPCC processes and outcomes in relation to different schools of thought on science–policy interactions in the next section. This is followed by a discussion of the notion of policy relevance and the role of IPCC processes and outcomes in this respect. Based on this, we outline four ideal types of potential IPCC reforms.

IPCC PROCESSES AND OUTCOMES

An informed discussion about the future of the IPCC needs to be rooted in the role it has played so far. According to the principles governing IPCC work:

> '(t)he role of the IPCC is to assess on a comprehensive, objective, open and transparent basis the scientific, technical and socio-economic information relevant to understanding the scientific basis of risk of human-induced climate change, its potential impacts and options for adaptation and mitigation. IPCC reports should be neutral with respect to policy, although they may need to deal objectively with scientific, technical and socio-economic factors relevant to the application of particular policies'[14].

This mandate reflects that policy relevance is at the core of the IPCC's workings. The first part of the mandate pertains to the assessment process itself, which shall be comprehensive, objective, open and transparent. The second part points to the main outputs, or outcomes, of the process, namely the reports, and stresses that these should be neutral, objective and relevant to policymaking. In this manner, the reports can contribute to new outcomes; for instance, policymakers can respond to the reports by developing policies. We will use the terms 'process' and 'outcome' as analytical pillars for organizing our discussions.

The two modes for creating and assessing policy relevance, focusing on process and outcome, were already highlighted in one of the early and seminal studies of the IPCC[15] (cf. ref. [16]). We argue that focusing on processes and outcomes, including IPCC reports as outcomes in their own right, is still applicable for analysing and discussing the IPCC and its workings.

IPCC reports contribute to shaping both policy discourses[17] and concrete policy outcomes[15,18], which again provide feedback to science and the IPCC. For instance, the emergence of the carbon budget conceptualization in the Fifth Assessment Report changed how parties to the UNFCCC understood climate change and, consequently, the design of the Paris Agreement, perhaps most notably the net-zero clause in Article 4.1[19]. Mitigating climate change is not just about reducing emissions but bringing them to net-zero. This outcome again influenced the IPCC assessment process when the UNFCCC invited the IPCC to produce the Special Report on Global Warming of 1.5 °C (SR15) and the consequent flurry of net-zero pledges. This example shows that the ways in which IPCC knowledge is generated, both in terms of processes and outcomes, have a bearing on the relevance of knowledge. Even though the processes and outcomes of the IPCC are intimately interlinked, it is useful to analytically distinguish the two elements when we discuss how to make the IPCC fit for new challenges.

The IPCC operates in a world rife with disagreements about the interrelationships between science and policy[13]. The initial IPCC process was tasked with assessing climate change as a physical phenomenon and response strategies through an explicit advisory function[20–22]. However, in the wake of the First Assessment Report published in 1990, an Intergovernmental Negotiating Committee was established, the precursor to the UNFCCC[23]. In other words, a division of labour between science and policy was introduced, illustrating that science and politics were understood as two separate societal spheres. This idea is often referred to as the linear model of expertise: knowledge first, then action[16,24]. This perspective is still prevalent, both in the real world and in scientific literature. However, this is not the only perspective; there is still significant disagreement about how intimately science and policy interact and how they should interact.

In the scientific literature on the IPCC, Sundqvist et al.[25] identified two ideal types of descriptions of IPCC: the two-world and one-world perspectives. The two-world perspective commonly holds that science and policy are quite distinct worlds, and they should be held separated until scientific consensus has been reached; science can then speak truth to power (cf. ref. [26]). If power does not listen, it is either because science has been infused by politics and is therefore biased or because power has priorities other than listening to science. In contrast, the one-world perspective contends that science and policy are inextricably intertwined[27]. If we do not act in accordance with scientific orthodoxy, it is because we have not managed to come up with clever ways of producing actionable knowledge in a meaningful way. The prescribed solution is often to come up with better ways of producing actionable knowledge, often through so-called normative co-production[28], implying that multiple actors, voices and perspectives are included in the knowledge production process. According to Sundqvist et al.[25], the tension between these two perspectives is in a state of impasse where no actor can legitimately claim to have the final answer. Thoni and Livingston[29] built on and expanded the one-world/two-world framework and argued that, rather than seeing these as two distinct ideal types, the one-world/two-world framework could rather be seen as a continuum, from separation to integration of science and policy (see also ref. [30]).

We will later return to this discussion and show how the one-world/two-world perspectives can inform discussions on IPCC reform. Before that, we will dig deeper into the scientific and political discussions about the policy relevance of the IPCC.

RELEVANCE FOR POLICY AND CLIMATE ACTION

Policy relevance is central to the IPCC, and thus far, the member governments of the IPCC are *the* prime target group for its reports. The IPCC Plenary effectively commissions a report for its own consumption. The initial task of the IPCC (in 1988) 'was to prepare a comprehensive review and recommendations with respect to the state of knowledge of the science of climate change, the social and economic impact of climate change, and potential response strategies and elements for inclusion in a possible future international convention on climate'[31]. Thus, the IPCC was conceived with a view to policy relevance, and this has continued to be a key characteristic.

In 2023, the IPCC on its website sums up its objective as 'to provide governments at all levels with scientific information that

they can use to develop climate policies'[32]. This implies that policy relevance is still at the heart of the IPCC's activities[18], and the member governments are still a key target group. The ambition to be policy-relevant without being normative is often expressed as the work of the organization to be 'policy-relevant and yet policy-neutral, never policy-prescriptive'[33]. This phrasing is rooted in a two-world view of the science–policy interface. Several IPCC scholars have questioned whether it is desirable or even possible with a (perceived) arm's-length distance between science and policy (e.g., refs. [23,34]). Furthermore, when the boundaries between science and policy are blurred, it is challenging to differentiate between relevant and prescriptive science.

It is not hard to find examples of the IPCC influencing policy decisions. Indeed, the Paris Agreement itself can be seen as a major achievement in this regard. Even though there are no formal, direct or explicit links between the Paris Agreement itself and the IPCC, it seems very unlikely to have emerged without the IPCC. Still, the Paris Agreement poses new challenges to the policy relevance of the IPCC, as the very design of the Paris Agreement, composed of commonly agreed-upon global goals, nationally determined contributions and a common mechanism to raise ambition, creates new knowledge needs[18]. It is unclear what roles the IPCC can and should take to be relevant to climate action under this new polycentric governance architecture[34].

The week before the Paris summit, the then recently elected IPCC chair stated in an op-ed in the scientific journal *Science* that:

> '…it [the IPCC] will better serve global policy-makers by providing a more in-depth, and clear, understanding of the solutions. The focus on solutions will be a major component of my tenure at the IPCC'[35].

Commentators have subsequently argued that the IPCC has entered a solution-oriented mode[36,37]. Still, there are still many reasons to question whether the IPCC is set up in a way that allows it to present the knowledge needed to facilitate a better 'understanding of the solutions'.

Even though the IPCC by design is policy relevant, what is meant by policy relevance and how it is achieved—not least across different contexts—are questions that merit more scholarly attention. These questions are important to discuss because of the performative nature of climate science, blurring the lines between policy relevance and prescriptiveness, especially after the Paris Agreement[23,34,38]. The IPCC is influential in defining corridors for climate action[39]; hence, it is challenging for the IPCC to strengthen its role as a knowledge provider for climate solutions while still claiming to be policy neutral[40]. In the following section, we discuss in more detail how the IPCC pursues its objective of being policy-relevant and solution-oriented, both regarding processes and outcomes.

IPCC PROCESSES, PROCEDURES AND SUB-ORGANIZATIONS

When discussing potential reforms of the IPCC, it is important to understand how this complex organization functions and operates. In the following, we explain this, based on the IPCC's formal guidelines and website, literature on the IPCC and the personal experience of the two authors that have served as IPCC Lead Authors. The IPCC is an intergovernmental body that engages both scientists and government representatives. The IPCC Plenary consists of government representatives from all 195 member governments, and it is the panel's highest decision-making body. All major decisions are made by the Plenary. It makes consensual decisions on budgets, work programmes, principles and procedures, as well as the structure and mandate of IPCC working groups and task forces[41]. The Plenary also decides on the scope and outline of the reports, approves the draft Summary for Policymakers (SPM) line by line and adopts and accepts the underlying reports prepared by the scientists. Finally, and importantly, the panel elects the IPCC Chair and the Bureau, the 'leader group' of the IPCC.

The IPCC does not hire scientists nor cover their time or costs, but in some cases travel costs and accommodation for some authors and Bureau members from developing countries are financed by the IPCC Trust Fund, which is funded by IPCC member governments. Most authors are supported by their government or scientific institutions, e.g., through their faculty positions.

The IPCC has developed a complex procedure for assessing and synthesizing peer-reviewed published scientific literature[10]. In principle, the IPCC does not conduct research on its own but critically assesses and synthesizes the relevant literature. However, the line between assessing and conducting research is not always clear, with different practices of assessment and research across working groups, chapters and sections, and over time. The IPCC process has a huge influence on research agendas. For instance, modelling communities (e.g., Earth System Models and Integrated Assessment Models) have organised themselves and coordinated their work around IPCC processes, timing and needs (e.g., through common databases)[42–44]. This contributes to blurring the line between research and assessment[45]. IPCC authors are often, sometimes for good reasons, assessing the literature to which they themselves have contributed. Strong networks can emerge through IPCC work[46], but there are few studies on the effects of these networks.

Many IPCC procedures aim to carefully orchestrate when and how science and policy meet[41,47,48]. At some stages in the assessment cycle, science and policy meet explicitly through designated interfaces, such as final decisions regarding draft outlines and the approval of SPMs[49,50]. At other stages, such as drafting reports, scientists work independently from policymakers (the Plenary). In the following section, we describe the IPCC assessment process in more detail.

Member countries nominate candidates and elect the IPCC Bureau[51]. Each report cycle then starts with member governments, observer organizations and the Bureau nominating experts to take part in scoping meetings[52]. The resulting draft outlines are then discussed and approved by the IPCC Plenary. The scoping meetings are important for the ensuing reports, as IPCC authors are required to respond to all bulleted points in the outline (see also ref. [53]).

Member countries, observer organizations and the Bureau then nominate experts as potential authors (ref. [53] p. 42). The final decisions regarding authors are made by the IPCC Bureau, with a view to also securing balance in terms of expertise, geography and gender (ref.[54] p. 63). It is standard practice for the authors to first develop a zero order draft (ZOD), which is subsequently reviewed by IPCC authors from other chapters. After this, the authors begin preparing a first order draft (FOD), which is reviewed by external experts including governments[10,48]. All relevant experts are invited to comment on draft reports, and IPCC authors must provide a written response to all comments. The response to the expert comments however need not be elaborate and can be a short response like 'Noted', 'Not relevant'. All comments and responses are made publicly available online. Second order drafts (SODs) are distributed to both experts and governments for review, along with the first draft of the SPM.

The SPM is regarded as the prime policy-oriented output. Based on the feedback from this review, the authors adjust their chapters and prepare final drafts of both the main report and the second order draft of the SPM. At this stage, only the draft SPM is reviewed by governments. Comments are integrated into a final 'floor draft' of the SPM that is submitted to governments before the SPM is approved in the IPCC Plenary, line by line, figure by figure. Although the SPMs are adjusted and altered during the approval process, the approval shall signify that there is consistency between the SPM and the underlying reports. If a

consensus is not reached on parts of the text or figures, those sections may ultimately be removed from the SPM[50]. Governments have in principle no direct influence on the underlying reports in the approval, but there are 'trickle backs' that ensure consistency between the underlying report and the SPM (e.g., if the name of a scenario is changed).

IPCC procedures and processes have evolved over the decades and become increasingly formalised[48]. By contrast, IPCC outputs (assessment reports, special reports and methodological reports) have been remarkably stable[16]. Yet, the IPCC's primary 'raw material', peer-reviewed science, has grown exponentially in the same period[10,55]. This poses new challenges to the IPCC, for instance, how to balance and compose different scientific disciplines within the IPCC, how to make these disciplines work well together, and how authors can rigorously assess all the relevant available science while responding to policymakers' and other actors' growing need for holistic and actionable knowledge.

The IPCC Plenary has significant authority over the IPCC procedure[52]. As the reports are commissioned by and written for the member governments of the IPCC, they, by definition, meet the policy relevance defined by the IPCC Plenary. That said, there does not seem to exist a common understanding of what policy relevance means. The consensus principle is central to the IPCC. However, consensus does not necessarily mean full agreement. Different countries have very different views on what policy-relevant knowledge is. Furthermore, what is relevant knowledge for actors engaged in climate governance and climate action may not align with what is policy relevant – or desirable – for the collective 195 governments that comprise the IPCC. It is well established that the integration of actors and perspectives into knowledge production processes may increase the usability of the knowledge produced[28,56]. On the other hand, wide inclusion, including vested and powerful economic and political interests, may also dilute science. There are no easy answers to these questions and dilemmas.

We believe that a discussion about the IPCC and its future will be most fruitful when creating room for nuance and different perspectives. To facilitate a fruitful exchange of ideas, Table 1 provides a stylized overview of key sub-organizations in the IPCC, as well as key processes and whether they are science–policy interfaces, primarily scientific or political in nature. Sometimes, science and policy actors and concerns meet through specific interfaces; sometimes, science works in (physical) isolation from policy; and sometimes, politics makes decisions about science. At the same time, it is impossible to rule out whether scientists have policy in mind when they write (which inhibits the risk of self-censorship) or whether policy influences science, e.g., through reviews and approvals. This means that both the one-world and the two-world perspectives have merit in explaining IPCC processes. However, rather than having a black–white perspective on the relationship between science and politics in the context of the IPCC, we in this special collection are interested in exploring different shades of grey across different contexts. This also applies to the impacts of IPCC reports, to which we will now turn our attention.

IPCC OUTCOMES: COMMUNICATION, DIFFUSION AND USE

Immediately after approval, each report was launched at a press conference. Since 2012, the IPCC has had a communication strategy and team[57]. The IPCC's centrally planned communication efforts are primarily geared towards the international level, such as the UNFCCC, less so towards the individual member governments of the IPCC. However, many IPCC authors participate in outreach activities in individual countries, and in some countries, the IPCC focal points make a considerable effort to facilitate the dissemination of IPCC knowledge.

The structure, readability and promotion of IPCC reports are among the factors that determine how IPCC knowledge is received and its impacts. Different audiences may have varying willingness and ability to digest IPCC knowledge. When examining the influence and impact of the IPCC, it is not enough to detect how it feeds knowledge into global negotiations. Rather, a range of actors across multiple levels and contexts are influenced by the IPCC (e.g., countries, cities, companies, civil society), or strategically refer to the IPCC to anchor and legitimize their climate governance decisions—or challenge such decisions and catalyse more climate action[17,18,57]. Overall, the impact of IPCC processes

Table 1. Science and policy elements in IPCC suborganizations and processes.

IPCC suborganizations and processes Science/policy dominance	Suborganizations	Key processes
Science–policy interfaces	National focal points	Nomination and election of Bureau members
		(Some) participation in panel- and scoping meetings
		Nomination of candidates for scoping and authors
		Organize governmental reviews
	The IPCC Bureau	Advise the Panel
		Nomination and selection of authors and editors
		Organize scoping
		Facilitate writing and review processes
		Lead SPM approval
Science	Chapter teams	Chapter and SPM writing
		Responding to reviews
	TSUs	Organize writing process
		Organize author meetings
		Organize expert review
		Editors of reports
		(Contributing) authors to some sections
Politics	The Panel	Commission reports, approve draft outlines
	UNFCCC	Endorse, welcome, or note reports

and outcomes on global, regional and national policies and practices is an understudied field[58].

Generally, there is little agreement on how to conceptualize and measure the influence and impacts of IPCC knowledge[59–61]. There are few detailed scientific studies of this, with some notable exceptions (e.g., refs. [17,62,63]). Variation in impacts across actors, contexts, policy levels[18] and geographies[64] are lines of scientific enquiry where a lot of work remains to be done. The complex relationship between climate governance and climate research makes such research challenging. The interrelationships run both ways, new political objectives and demands influence the scientific agendas and the scientific developments enable new political developments[19,45].

These questions are particularly interesting in a post-Paris policy landscape. How IPCC knowledge will feed into the Global Stocktake under the Paris Agreement and whether and how it will contribute to ramp up ambition in the Paris Agreement are still open questions. All member countries of the IPCC also develop and implement policies to fulfil their NDCs, but we still do not know how IPCC knowledge feeds into these processes or how this varies across contexts. The same applies to the roles of national focal points in this process. More broadly, how and why different countries validate and respond to 'global knowledge'—or civic epistemologies, to put it in Jasanoff's terms[65,66]—is an area where much work remains to be done[58].

Most IPCC studies have had a prime focus on the internal processes in the IPCC and thus an *inside* view of how policy relevance is made through IPCC processes and procedures. This special collection also calls attention to *outside* actors and processes in the post-Paris landscape. Similarly, we should be open to differing ways of engaging with IPCC knowledge. Actors may interpret and use IPCC outputs for multiple purposes and with varying consequences[17]. Further, we can learn more about the role of IPCC by examining the strategies actors employ to engage with the knowledge, such as translating it into more workable formats for specific target groups or using more confrontational tactics to drive climate change up on the political agenda. To better grasp the roles of the IPCC, we need more knowledge about the dynamics between inside and outside actors in the IPCC, their strategies and the impacts of their practices.

FOUR STYLIZED REFORM AGENDAS FOR THE IPCC

Earlier, we presented two analytical dimensions: the policy relevance dimension spanning processes and outcomes and the science–policy dimension spanning the one-world (intertwined) and two-world (linear) science–policy perspectives. Even though the two dimensions are not clear-cut dichotomies in practice, they can help us develop four clearly distinguishable reform agendas. When we combine these analytical dimensions with what we know about IPCC processes and outcomes, we can differentiate four different answers to the question we posed initially: *How can IPCC processes and outcomes be reformed to produce knowledge that is more relevant for climate action?* Clearly defined IPCC reform agendas can help facilitate discussions about how to cope with the challenges facing the IPCC, even though reform in practice may end up mixing elements from several alternatives. In Table 2, we specify four ideal-type reform agendas for the IPCC. All can contribute to ensuring that the IPCC continues to produce relevant knowledge for climate action. We consider the organizational and resource constraints of the IPCC when we lay out the four options.

The *Back to Basics* reform agenda builds on the two-world view that science and policy can be quite clearly delineated (cf. ref. [26]). It is aimed at improving IPCC procedures without requiring much more resources. To some extent, this is business as usual, with scientists and government representatives continuing to meet and have a dialogue at given critical stages in the IPCC process. However, due to the explosion in climate research, the IPCC does not have the capacity to carry it on just as before. The IPCC has to prioritise. For instance, it could give priority to science that feeds directly into discussions about global emissions and ambition levels (collective action), specifically the physical climate sciences and Integrated Assessment Modelling. Another example could be concentrating more on knowledge relevant to physical climate risk assessment. Here, the legitimacy of the IPCC is upheld by insisting on strict demarcations between science and policy and enhancing transparency in existing processes, not by assessing more scientific literature on policy and governance issues or by including more actors and perspectives in the process itself. Because fewer researchers and disciplines are included, the process becomes more streamlined, and more attention can be given to coping with the increasing amount of science. The IPCC zooms in on the needs of its main audience, the IPCC member governments and the UNFCCC negotiations, particularly the Global Stocktake.

The *Tailored Broadcasting* reform agenda shifts resources and attention towards IPCC communications. Authors get more guidance on developing simpler and more accessible language in the reports, the press conferences and information material improve and, in collaboration with national focal points and other partners, the IPCC hosts a range of communication events directed at diverse international and national audiences, both in the public and private sector. The IPCC has already improved its communication but still draws criticism[57]. The increased communication efforts are not aimed at spurring dialogue as such, but rather at facilitating and improving one-way dissemination. This reform agenda requires a shift in how IPCC resources are spent, away from the production of reports and towards their distribution, including the production of derivative products (such as tailored knowledge products targeted towards specific user groups). Producing short, accessible reports with updated information may also be conducive to dissemination. Hence, we may see slimmer assessment reports and a development towards special reports tailored to the knowledge needs that countries identify in the UNFCCC and IPCC Plenary meetings. In this strategy, the legitimacy of the IPCC is underpinned by the IPCC's ability to communicate clearly and understandably.

In *Orchestrating Broad Knowledge Generation*, the IPCC acknowledges and embraces its role as a key node within the broader ecology of climate knowledge generation[67,68]. The IPCC acknowledges that it is not the only international climate knowledge provider and collaborates actively with others. It will identify other key knowledge organizations and treat these as complementarities and intermediaries that can perform knowledge generation and roles it does not have the capacity to do itself, such as the International Energy Agency (IEA), United National Environment Program (UNEP) and/or the International Climate Council Network

Table 2. Four ideal-type reform agendas for the IPCC, spanning the dimensions of policy relevance (process and outcome) and science–policy (two-world linear and one-world intertwined).

	Process orientated	Outcome orientated
Two-world perspective	Back to basics	Tailored broadcasting
One-world perspective	Orchestrating broad knowledge generation	Reflexive learning

(ICCN). The IPPC will use soft measures to influence these and also ensure co-ordination between them. This model also implies a reconsideration of the current working group structure. The IPCC will include more actors for identifying special reports and scoping procedures. The IPCC will not merely aim to identify robust scientific conclusions but also actively aim to spur coherence in scientific debates and shape and change research agendas. Here, IPCC legitimacy will rely on its ability to identify knowledge needs and act as a facilitator for the research community at large. Notably, within this alternative science and policy spheres will still be driven by differing dynamics, but there will be more—and more transparent—interactions. Even though the linear view of science–policy is abandoned, the IPCC will need to ensure that it follows classic scientific procedures. This will be resource demanding and the IPPC has to mitigate risks of vested interests tapping into knowledge production processes.

Lastly, the *Reflexive Learning* reform agenda facilitates deep learning and blurs the distinction between process and outcome. Here, climate knowledge and policy options are generated through ongoing learning processes, where everyone involved update their beliefs based on knowledge from a variety of sources: experiences, social interaction and scientific analysis[69]. This would require a dynamic approach, very different from how the IPCC operates now. It would require the IPCC to create multiple spaces for deliberation and reflection, where scientists, policy makers, NGOs, corporate actors and others listen to each other and re-consider one's preferences[69]. Moreover, governments, corporations and NGOs that perform experimental climate governance, need to systematically track effectiveness, efficiency and justice, and allow researchers to take part in reviewing their efforts[70]. This reform agenda is very resource demanding.

Here, the legitimacy of the IPCC relies on its ability to respond nimbly to its surroundings, cater to different knowledge needs, remain in constant dialogue with many different actors, learn from what goes on outside science and provide quick assessments to a broad array of audiences. IPCC focal points would need to play a key role in mediating between different countries' and actors' knowledge needs and the activities of the IPCC.

This approach seems harder to align with strict scientific procedures, as well as the hierarchical structure with the Panel commissioning reports and approving outlines. This also implies that the current working group structure may be abandoned. This reform agenda is the most radical of the four options outlined here. It shifts the whole IPCC venture away from identifying scientific truths and towards a more action-oriented IPCC, which is more directly relevant for everyone involved in climate transformation. This cannot happen without fundamental changes to IPCC procedures. For instance, the IPCC will need to loosen its ties to the member governments, identify and engage with other governmental and non-governmental actors of relevance for climate action and include these and the knowledge they possess in the process of producing actionable knowledge. It would also require capacity building in developing countries. A parallel in terms of how to engage with governments could be how the WHO operated during the COVID-19 pandemic[71].

CONCLUSION

The IPCC has done a pivotal job of enabling society to understand climate change and contributing to putting it on societal and political agendas. What roles the IPCC can and will take in an era of deep decarbonisation and transformation is an open question. Efforts to increase our understanding of climate solutions and climate action will likely be very resource demanding—not least because 'societies are complex and are in many ways harder to study than cells in a petri dish'[72].

After 35 years of operation, researchers of various backgrounds have experience in IPCC work. In parallel, a large body of scholarship on various aspects of the IPCC has emerged. One of the aims of this special collection is to spur dialogues across different communities, both IPCC insiders and those who study the IPCC, including different schools of thought within science–policy relations. Given that the IPCC was set up to serve a different purpose than the polycentric governance pattern we see today[73], it is unclear whether the IPCC processes and outputs are designed in ways that facilitate the creation, accumulation, diffusion and translation of the types of knowledge that we need to better cope with climate change. Furthermore, the IPCC has limited resources that put severe constraints on its workings.

This introduction piece presented four stylized reform agendas but did not assess their realism or desirability. We hope this introduction and the special collection itself, with its empirical investigations of the IPCC's relevance for climate action, can feed back lessons to the IPCC and thus help it become more of a reflexive learning organization[74]. Such empirical investigations can also be useful for actors relating to the knowledge presented by the IPCC, helping them better understand both the organization that produces the knowledge they relate to and the knowledge itself. This is important, since climate transformations are essentially collective learning exercises, and feedback cycles are key in learning.

DATA AVAILABILITY

All data that can be made available is accessible; see references.

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Erlend A. T. Hermansen[1]✉, *Elin L. Boasson*[1,2] *and Glen P. Peters*[1]
[1]*CICERO Center for International Climate Research, P.O. Box 1129 Blindern, 0318 Oslo, Norway.* [2]*Department of Political Science, University of Oslo, P.O. Box 1097 Blindern, 0317 Oslo, Norway.*
✉*email: erlend.hermansen@cicero.oslo.no*

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AUTHOR CONTRIBUTIONS

E.A.T.H. wrote the first version of this introduction, contributed to conceptualizations (development of theoretical framework in particular) and literature reviews, and had the main responsibility for responding to review comments. E.L.B. contributed to conceptualizations (development of the tables in particular), literature reviews, the review process and editing, and she drew on her experience as an IPCC lead author. G.P. contributed to discussions about conceptualizations and was active in the review process and editing. He also drew on his experience as an IPCC lead author.

COMPETING INTERESTS

The authors declare no competing interests.