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Science for transformative change: the IPCC, boundary work and the making of useable knowledge

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While there has been much discussion about what kind of expertise the IPCC needs to develop to (better) guide climate policy, little has been said about how the experts themselves assess the challenges of making science policy-relevant. The paper aims to address this gap by exploring how leading IPCC experts reflect on and evaluate their work. The empirical material consists of an interview study with experts currently or recently involved in the IPCC. The selection strategy aimed to achieve a broad range of experience among those with key roles in the assessment work, including experts from all three working groups, from different regions, and of different genders. Data from the interviews was analyzed thematically using NVivo. The concept of boundary work was used to analyze the distinctions and boundaries in this work; how the IPCC experts draw boundaries between science and policy, between policy-relevance and policy-prescriptiveness, and between certain and uncertain knowledge. By analyzing the experts' own experiences and ideas about what makes science relevant to policy-making, the paper contributes to the discussion about current and future challenges for the IPCC.

KEYWORDS

boundary work, expertise, IPCC, science-policy relation, science-policy interface, social transformation

1 Introduction

The Intergovernmental Panel on Climate Change (IPCC) has been successful in disseminating scientific knowledge about climate change, its nature, its causes and options for action. This expert organization has the epistemic authority to summarize the state of knowledge in the field of climate change, a unique position of providing expert advice, and very good relations with the policy work carried out under the United Nations Framework Convention on Climate Change (UNFCCC), and it has successfully influenced the international climate policy agenda (De Pryck and Hulme, 2022). Without the work of the IPCC, the Paris Agreement, with its goal of limiting global warming to well below 2 degrees, would probably not have come about (Lidskog and Standring, 2023). Few, if any, expert organizations can claim such success, and the IPCC often serves as a model for other expert organizations that produce global environmental assessments of different environmental issues.

However, the IPCC has had limited success in influencing the national policies implemented under the Paris Agreement and the commitments (nationally determined contributions) that countries are now developing. Despite the growing understanding of

climate change and the urgent need to rapidly create a fossil-free society, climate emissions continue to rise (Stoddard et al., 2021). This has led to a major debate about whether the IPCC should change, with some researchers arguing that its institutional design and approach to science-policy relations need to change to make it more relevant to decision-makers (Asayama et al., 2023; Beck and Mahoney, 2018; Berg and Lidskog, 2024; Hermansen et al., 2023; Lucas, 2021a; De Pryck and Hulme, 2022).

This discussion also raises the broader question of how to improve the science-policy interface and develop expert advice that is credible and useful for the work of transforming society (Castree et al., 2021; Heink et al., 2015; Kirchoff et al., 2013; Lidskog et al., 2022; Rantala et al., 2024). The topics discussed range from what strategies scientific expertise should develop to better influence society (e.g., Hermansen et al., 2021), to how science should change internally (Haas and Stevens, 2011), how expert organizations should develop and what roles they should take (Guston, 2000; Miller, 2001; Pielke, 2007), and overarching and far-reaching proposals for a new contract between science and society (Nowotny et al., 2001), including new policy mechanisms for the uptake of scientific recommendations (Sundqvist and Linke, 2024) and better accountability structures (Lucas, 2021b). A recent example of the latter is the independent scientific assessment of the UN Sustainable Development Goals, which states that what is needed now is a transformed science that is more inclusive and transdisciplinary, more responsive to societal needs, more transparent, and more interactive with knowledge users (ISG, 2023, p. 89).

Maintaining scientific authority while striving for policy-relevance is a complex undertaking, especially when far-reaching decisions and policies are needed that will affect most sectors of society. This is the reason for the ongoing scientific debate on how to improve the science-policy interface. The current threat of political polarization (Rekker, 2021; Rughiniş and Flaherty, 2022) and the internal threat of disciplinary fragmentation (Gauchat, 2023) have brought the question of how to make science trustworthy and credible into focus, and both science communication (Hall Jamieson et al., 2019; König and Jucks, 2019) and institutional conditions (Gundersen and Holst, 2022) are considered important for the public trustworthiness of science and scientific advice.

There are many studies of the IPCC as a boundary organization, that is, an organization that brings science and politics together (Hoppe et al., 2013; Beck and Mahoney, 2018; for an overview, see Gustafsson and Lidskog, 2018), but few studies have analyzed how the experts themselves reflect on and draw boundaries in their assessment work. Similarly, while there has been much debate about what kind of expertise is needed to support and guide transformative change (see, e.g., Chambers et al., 2021; Pielke, 2007; Turnhout and Lahsen, 2022), little has been said about how the experts themselves assess the challenges of being an expert (for an exception, see Jagannathan et al., 2023).

This paper aims to address this gap by exploring how scientific experts involved in the IPCC reflect on and evaluate its efforts to make science policy-relevant, based on an interview study with researchers currently or formerly involved in the IPCC assessment work. It uses the concept of boundary work to analyze how they perceive the IPCC's distinction between science and policy, and how it navigates the demands of being both scientifically trustworthy and politically relevant. In particular, the paper analyzes how boundaries are drawn between science and policy, between policy-relevance and policy-prescriptiveness, and between certain and uncertain knowledge. By exploring the experiences and perspectives of experts involved in making science for policy, this study contributes important knowledge to the current discussion on how science can better influence the work for social transformation.

2 Research design

2.1 The conceptual approach: boundary work

The sociology of science has long been interested in investigating different types of boundaries and how they function for actors and institutions. Rather than postulating what belongs to the political and scientific spheres, it examines boundaries and sees them as shifting. Thomas Gieryn (1995, 1999) has introduced the concept of "boundary work" as a central mechanism for conferring authority on science. In his studies, he shows how epistemic authority is created when an expert group carves out and controls a particular domain of knowledge, disregards or devalues other knowledge claims within it, and thereby becomes the dominant provider of knowledge within that domain. He also shows that there are no absolute criteria for distinguishing science from non-science. Instead it is constantly being reshaped in different settings and by different actors. This means that epistemic authority is not an inherent property of science, but is constantly enacted in people's talk, decisions and actions. For Gieryn (1999, p. 23), boundary work is a strategic, almost instrumental, action; there are social interests behind the drawing of boundaries. In doing so, it also becomes functional; it is a useful way of persuading audiences and mobilizing support for a position, decision or action.

Drawing on cultural theory (Douglas, 1991; Douglas and Wildavsky, 1982; Thompson et al., 1990), Swedlow (2007, 2017) elaborates on the concept. He shows how boundary work relies on claims about pollution and purity. By arguing that a statement, theory or perspective is contaminated by non-scientific factors, a clear boundary is drawn between science and non-science. For example, if scientists work closely with an industrial interest, some may claim that this collaboration produces contaminated knowledge, as opposed to pure scientific knowledge untainted by special interests.

Thus, boundaries are drawn not only between science and society, but also within the scientific community itself, distinguishing between pure science and biased ("polluted") science (Swedlow, 2017). Scientists may, for example, perceive other scientific claims, methods, and results as tainted by industrial interests or ideological commitments, while viewing their own research as pure and unpolluted by non-scientific factors (Swedlow, 2007).

The concept of boundary work is used as an analytical tool in this study, which explores boundaries drawn within an expert organization (IPCC) when discussing how to make science policy-relevant. Hence it examines the boundaries they draw themselves, not boundaries they observe others drawing. In other words, the interview study is mainly about the experts' own beliefs and views, although they may contrast their position with others, or talk about how they have to struggle within the organization to make room for their positions.

This means that this study accepts the meaning of the concept given by Gieryn and Swedlow, but differs somewhat in its focus. It shares the focus on how to achieve and maintain the credibility of

science, and the contention that boundary work is central to this. It also shares the view that boundaries are dynamic and changing, but often routinely and unreflectively reproduced. It differs, however, in that it does not focus on explicit struggles over issues or dramatic shifts in policy, where boundary work is central to legitimizing or delegitimizing positions in a conflict. Although boundary work always functions to legitimize certain positions and de-legitimize others, boundary work is more strategic and explicit in conflicts (for example, such as the debate between climate scientists and climate denialists).

2.2 The case of the IPCC

The IPCC is the United Nations body charged with assessing the science of climate change. It is a boundary organization involving both politics and science (Guston, 1999). Governments (and organizations with observer status) nominate scientific experts, and these experts select the material to be included in the assessment, assess it, write a preliminary version of the report, receive review comments from both external experts and governments, and revise the report. Finally, the IPCC panel approves and adopts the final report (see IPCC, 2024 for an overview of the process).

The IPCC is a learning organization and has adapted to its changing context (Beck and Siebenhüner, 2022). However, its fundamental structure has remained the same, consisting of three working groups that assess different aspects of climate change: the climate as a physical system (WG1), the impacts of climate change and how to adapt to them (WG2), and options for mitigating climate change, either by reducing GHG emissions or by removing GHGs from the atmosphere (WG3).

Assessing the science of climate change is an increasingly complex task. The most recent assessment (AR6) involved nearly 800 experts (coordinating lead authors, lead authors, review editors), reviewed more than 66,000 articles, and received 200,000 comments on its drafts, and the final versions of its three assessment reports run to more than 8,000 pages. The IPCC has also incorporated more aspects into its assessment. For example, the latest assessment includes more discussion of regional climate change and climate-related extreme events (WG1), links between climate change and other environmental and health issues, the role of cities and infrastructure (WG2), synergies and trade-offs between mitigation and adaptation, and social aspects of mitigation (such as consumption patterns) (WG3). As a result of the increased political and scientific recognition of the problem of climate change, there is now more and broader scientific knowledge to assess. In addition, the international community and states are increasingly calling for more solution-oriented assessments (the post-Paris political context), which also makes the work of assessment more challenging, as it must present options for action in order to be politically relevant while at the same time maintaining its scientific credibility and political neutrality (Beck and Mahoney, 2018; Hermansen et al., 2023).

Research has shown that boundaries are dynamic, and that even the seemingly fixed boundaries of an organization can be challenged or ignored in practice. Organizational studies have shown that organizational hypocrisy—the discrepancy between talk, decision, and action—is not an exceptional occurrence, but is a constitutive part of organizational life (Brunsson, 2007, 2019). Many organizations are trying to satisfy different, conflicting external demands and are made up of people with different values, and organizational hypocrisy is one way—whether unconscious or strategic—of dealing with these conflicting demands. By decoupling decision and action, some demands can be satisfied by talk or decision, and others by action. This means that it is important not to limit a study of boundary work to what an organization does on the front stage and what it says in formal guidelines and written documents, that is, to what is communicated externally (assessment reports) and promoted internally (assessment guidelines). Backstage, in the internal work and life of an organization, there may be a variety of views about what boundaries are important and where they should be drawn. Because of the internal diversity of the IPCC, which brings together scientists from different research fields and traditions, it is reasonable to assume that there is a wide range of ideas about how science can become policy-relevant while maintaining its scientific legitimacy. It is therefore of great interest to explore what experts involved in producing IPCC assessments consider important in making science relevant to climate policy without compromising its legitimacy.

2.3 The empirical study

The selection strategy aimed to achieve a broad range of experience among those with key roles in the assessment work. As part of this strategy, the composition of the participants would also reflect the composition of the IPCC experts in general, in the sense of including experts from all three working groups, from different regions, and of different genders.

Another selection criterion was that the experts should currently work or have recently worked within the IPCC and therefore be familiar with the current way in which the IPCC works. Many of the participants had also been involved in previous assessments, which provided opportunities to ask questions about historical changes in IPCC assessment practices and how they evaluate these changes.

The interview study was conducted digitally with 18 participants in 2020. Eight of these had been involved in only one assessment (most of them in the most recent ones, AR6), seven in two or three assessments, and three in four or more assessments. Some had served as experts in different working groups; of the 18 participants, four had served in both WG 1 and WG2, and two in both WG 2 and WG3. Thus, although the interview study includes only 18 experts, they represent a considerable breadth of experience with the IPCC. More information on the composition of the interview study can be found in the Supplementary material.

The interviews were conducted between March and November 2020, lasted between 60 and 90 min, and were conducted digitally. They were conducted in English, recorded, and transcribed verbatim. The interview study was semi-structured around six topics:

- Involvement, motivation, and implications for your academic career.
- Similarities and differences between your work as an IPCC expert and your work at a university/research institute.
- Interdisciplinarity: why and how has it been used in the assessment work? Your evaluation of the barriers and opportunities for collaboration with other disciplines and research traditions.

- Opportunities and challenges that you see in the assessment work.
- Future challenges for the IPCC and what competences are needed to address them.
- Science for policy: what role does the IPCC play in climate policies, and what role should it play? What are the challenges for the IPCC in its efforts to be policy-relevant?

2.4 Analysis

The data from the interviews was analyzed thematically, using the interview guide to extract themes. NVivo 12 Pro qualitative data analysis software was used to conduct contextualized thematic analysis (Bryman, 2012, pp. 578–581). The transcripts were broken down into themes (with subthemes). Of the eight themes constructed (with 36 subcategories), four were considered relevant to this paper, namely, "expert practices," "view of science," "policy-relevance," and "the future IPCC."

In order not to lose the context of what was said when quoting participants, information is also given about the working group in which they were involved. The reason for this is that the working groups have partly different disciplinary constitutions and focus on different issues. Additional information (such as disciplinary affiliation, assessment cycle, country) is not provided, to avoid revealing participants' identities.

2.5 Study limitations

Some limitations of the study should be acknowledged. First, there is an element of self-selection of participants. A list of relevant experts was compiled and then used to contact the experts. If an individual responded negatively, another individual with a similar profile was asked to participate. In addition, the participants were asked to suggest relevant persons for interviews, and some of these were added to the list to increase both the relevance of those selected and the response rate. In total, approximately 60 experts were contacted and 18 participated in the study. This means that about two-thirds of the invited participants decided not to participate (by not responding to our invitation or by responding negatively). A possible reason for this is time constraints, combined with digital fatigue (The interviews were conducted during the pandemic, which means that many work tasks had to be done digitally). However, there may be differences in the experience and evaluation of the IPCC between those who participated in the interview study and those who declined.

A second limitation is that the composition of participants reflects the composition of the IPCC experts in terms of gender (66% male in AR6, and 12 people in this study, i.e., 66% male), but not in terms of regional representation (35% from the Global South in AR6, but only three people in this study, i.e., 17%).

However, the study does not claim to be representative of the average experience of all IPCC experts. Rather, it seeks to explore how leading IPCC experts evaluate and reflect on the IPCC's work, with the aim of highlighting some central tensions that need to be considered when discussing the future of the IPCC. It is important to note, however, that the small sample (18 participants) does not capture the probably very diverse experiences of the IPCC. Its three working groups have different areas of focus, they review literature in different fields, and their respective areas of expertise have different disciplinary constitutions.

A third limitation is methodological. Thematic analysis runs the risk of losing the context of the interviews (what is said before and after a quote, and contradictions within the account). This can be further reinforced when using qualitative data analysis software; after coding, chunks of text are brought together into constructed themes, which are then decoupled from the full interview. To counteract this, the full interviews were reread after the themes were constructed, to avoid interpreting text chunks in a way that is inconsistent with what was said in the interview.

A fourth limitation concerns the risk that the research, through its analysis, reproduces old boundaries or invents new ones. Because the interview questions focus on boundary work, they may lead participants to overemphasize certain aspects, and the data analysis, which looks for boundary work in the interview material, may also lead to boundaries becoming more central to the study than they are in the assessment work. This is a characteristic of all research (surveys as well as interviews) that involves collecting data on people's views, beliefs and attitudes. There is no standard procedure for dealing with this other than to be sensitive to this risk and take it into account when interacting with the participants and analyzing the data (Glas, 2021; Savolainen et al., 2023; Soedirgo and Glas, 2020).

3 Analysis: experts' experiences and evaluations

The interview topic concerns how science can and should be made useful to decision-makers (understood by the participants almost exclusively as policy-makers). Several boundaries recurred in the interviews: the science-policy interface and the boundary between science and policy, and how to bridge it; the boundary between policy-relevance and policy-prescriptiveness, and the importance of not crossing it; the boundary between certain and uncertain knowledge, and how to make uncertain knowledge usable; and the role of consensual knowledge, and on which side of the science-policy boundary it should be located. Several other themes were articulated, but they were given a less prominent role (in terms of how much space an issue was given or how many of the participants that discussed it) or were discussed in a way that did not contain any (explicit or implicit) boundary drawing. An example of the former is that one participant discussed the difference between IPCC and IPBES and how it indicated partly different ways of making science policy-relevant, and an example of the latter is that several participants discussed how time consuming it is to be involved in the IPCC.

3.1 The IPCC as science-policy interface

Common to all participants was an emphasis on science for policy and the need not only to communicate research but also to produce policy-relevant science. They also thought that the IPCC has been largely successful in its work to influence policy.

> *I still find it basically somewhere on the spectrum from remarkable to miraculous that you can get countries to agree by consensus on*

> *summaries for policy-makers. /…/ it's pretty amazing that this approach to having government and science input can be made to work on an international scale, and there really is not anything else like it that's been successful and influential in the past.* (#6: WG1 and WG2).

None of the participants provided any explicit definitions of science and politics. However, they all drew clear boundaries between science and policy. On the basis of this demarcation, it is possible to reconstruct their view of science and politics and the difference between them. Two different overarching views emerged from the interview material.

One common view was that science is clearly separate from society and its values, and that the role of the IPCC is only to communicate scientific knowledge. This, in turn, creates an opportunity for policy to set priorities (based on its values).

> *You see, without science there is no, you could say, without science, no facts, no authority to speak, and we cannot speak about climate change without hearing the facts /…/ we need to prioritize and therefore we can only prioritize after knowing the facts and you can know the facts from the science. At the IPCC they provide the scientific background, the scientific information that we need to act. So the IPCC has so far given us a sense that it's enough for us to take action to combat climate change. So it is a very big success in that regard.* (#8).

According to this view, the IPCC is a scientific organization whose work should be seen as a purely scientific activity.

> *In the end, the reality is that the IPCC has, in a sense, a near monopoly on information, because policy-makers trust it and they use it. And the effect of the IPCC is to take arguments about science off the table at the climate negotiations and save everybody a lot of time.* (#10: WG1, WG2).

Another common view was that science is separate from society, but when it is made policy-relevant it incorporates political and value-laden aspects. According to this view, the IPCC is a hybrid organization whose mission is to influence policy, and therefore the IPCC cannot be described as purely scientific.

> *It was a massive jump, it was a new thing for me. I knew what the Working Group 1 report was about, I did not know anything at all in fact about the interface between science and policy and how that works in the IPCC. I'd never seen anything like that before.* (#5: WG1).

> *But what we have to write is not just about scientific reviews, it's more of an assessment that can be used by the policy-makers.* (#4: WG2).

Several participants pointed out that scientific legitimacy is necessary, but not sufficient, for the IPCC to be a trusted and authoritative voice in global climate policy. This is why the issue of representation and diversity has become so important to the IPCC. As one participant put it:

> *To put it bluntly, if you want a good, well-written report on any aspect of climate change, you could get half a dozen white European men to write it, and if you choose the right six white European men you will get a very good report. It would have a fraction of the impact that an IPCC report does because it just would not be seen as representative of the global scientific community or relevant to the body politic. And so, bringing that diversity is, I think, one of the things that are really essential, but also one of the things that are very challenging to do.* (#7: WG3).

It is interesting to note that the different boundaries did not seem to create internal tensions. The boundaries drawn by the participants were not intended to delegitimize other positions, but rather to create internal coherence among the participants, where some believed they were only contributing scientific knowledge and that the IPCC was about pure science, while others saw the IPCC's assessment and policy recommendations as impure, but thought this was not a problem because the IPCC is a boundary organization where science and politics meet.

3.2 Making science policy-relevant

Although there were differences in how participants viewed the relationship between science and policy, no tensions between different positions were articulated. Tensions did emerge, however, when participants had to answer questions about what constitutes policy-relevant science and how the IPCC makes science policy-relevant. Several participants developed their answers by contrasting them with other views that exist within the IPCC.

All participants agreed that the role of the IPCC is to provide scientific knowledge to decision-makers and that this knowledge needs to be made useful. Most felt this will require better collaboration and integration between disciplines. Three of the participants highlighted the IPCC's Special Reports as examples of successful integration, where a specific problem was in focus, and researchers had to work together to produce policy-relevant knowledge about the problem.

> *First of all, the 1.5 report was, I think, the first time that we ever had a fully integrated report. /…/ this report, if you look at the structure compared to the past, it has changed completely /…/ We said climate change is happening, unequivocally, we cannot go on with this kind of structure that said "you see, this is the observation evidence, this is the modeling evidence, this is incremental confirmation of the results." So, the aim was to make it more user-relevant and integrated, and so the whole structure was redesigned, and that is a characteristic of working with just one report, so each chapter brings people from different disciplines.* (#5: WG1).

> *Particularly in the special reports, they are truly integrated documents which do not have an A goes to B goes to C, it's not a linear relationship. /… / And for a long time, that [a linear view] caused a lot of problems, and it comes to a head when you have to make decisions involving risk management, because it's the human system and the physical system, the information has to be brought together.* (#10: WG1 and WG2).

This is a criticism of the fundamental IPCC structure of having three working groups with different tasks and different disciplinary compositions. In practice, these working groups draw boundaries between disciplines and knowledge that make it more difficult to make climate science relevant to policy.

Instead, several participants stressed that knowledge integration is crucial for generating policy-relevant knowledge, and some also emphasized the importance of the social sciences in this regard. At the same time, a number of participants—both natural scientists and social scientists—said that some natural scientists were critical of the inclusion of the social sciences. One participant, a natural scientist (meteorologist), explained this in the following terms:

> *The question quickly came up: what does it mean for society? And the situation immediately became much more difficult. For instance, for big companies, it's not really relevant what or how the climate would change, but the key issue is how climate policy will change. This is an attitude that is kind of taboo among natural scientists. They do not like that. Because they truly have something to say, but if you talk about this, they have very little to say. Actually, I would say they have very little to say now. I mean it's a completely different story that social scientists, political scientists have a lot to say, economists have a lot to say, it's alright because it all has to do with the question of how we deal with it. Also, engineers in the field of mitigation are important, engineers in the field of adaptation are important, but climate scientists are no longer all that interesting. For the public, I mean for ourselves, we are enormously interesting, of course.* (#2: WG 1 and WG2).

The participant found his or her own work to be very interesting from an intra-scientific perspective, but of limited value for current climate policy, where the challenge today is to develop policies and take action.

One of the participants even stated:

> *I am doing quite a bit of science, but I'm not doing very much on climate change because scientifically it has become boring. There is not much to be gained. The question now is what do we do about climate change?* (#2: WG1 and WG2).

Another, after saying that there are IPCC experts who mistakenly believe that all scientific analysis is based on quantification, said the following:

> *I'm a natural scientist, so I've done a lot of stuff with numbers, I like numbers, I get it, but I've spent enough time in the real world working with people from other disciplines and just reading the literature on this topic to know that this is not the way the world works.* (#11: WG2).

Both of these participants emphasize that science for policy is no longer about gaining a better understanding of how the climate system works, but about how to develop relevant political responses—mitigation and adaptation. This knowledge needs to be based on a better understanding of how society works, and what advice policy-makers will find relevant and actionable.

At the same time, there was a duality in the view of social science: it is needed in order to make climate science relevant to policy, but at the same time it complicates things, because it is not suited to giving general advice. One participant used the example of carbon taxes, saying:

> *I think the challenge I faced, and other social scientists faced, was sort of making the argument for the strength of the literature, because sometimes the literature was quite contradictory and not always clear cut, especially around policy solutions. They work in place A, but they do not work in place B.* (#17).

The participant emphasized that while a carbon tax can be a very effective instrument, in the assessment it is much harder to say that it is a good tool, because it is not universally applicable. This is a common theme among the social science experts interviewed; much of social science is context-sensitive and rarely lends itself to modeling.

Despite the problems they saw in developing policy-relevant science, all the participants considered it to be important and possible. Similar to above (section 3.1), the starting point for the participants was that climate change is a serious and urgent problem that society needs to prioritize, and that science has an important role to play in motivating and guiding climate policy. The problem here, for some of the participants, is the demand for purity made by some experts: that only a certain type of science—abstract, quantified, aggregated and preferably modeled—should be considered be the most mature and distinct, and should form the basis of the IPCC's advisory activities.

3.3 Relevant but not prescriptive

The mission of the IPCC is to develop knowledge that is policy-relevant, but not policy-prescriptive. This distinction between relevance and prescriptiveness is something that all participants agreed on, and they also agreed that the IPCC has largely succeeded in not crossing this line. One participant explained this by making a distinction between what is said in the assessment reports, and what is communicated to policy-makers and reported in the media:

> *Because in the IPCC, we are not policy-prescriptive, we are just passionately assessing the literature, and that's what we are told over and over again, and then when these things roll out, you see the heads of the IPCC talking about the urgency of action and saying things that sound a little bit or a lot like advocacy. And I think there's this tension between objective assessment and pushing, helping to support a policy agenda.* (#11: WG2).

In contrast to this view, some participants said that there are researchers with strong personal opinions—on geoengineering, for example—but that these opinions are handled in the assessment process.

The participants identified three main ways in which the IPCC manages to be policy-relevant without being policy-prescriptive. The first is to avoid talking about responsibility and instead to talk in terms of options and consequences. Not mentioning which actors emit greenhouse gasses is thus a very particular way of understanding policy-relevance which seems to have more to do with strategic considerations.

Another is to start from adopted goals and objectives—not least the Paris Agreement and the Sustainable Development Goals of

Agenda 2030. They argue that this makes it non-prescriptive in the sense that it only provides decision support for existing policies.

A third way is to frame the climate issue in accordance with existing frames and political understandings of climate change.

> *So, there are different levels of that, one is just to describe the sorts of communication challenges, opportunities and so forth that arise, the whole disconnect, the potential disconnect between all the things that need to happen between knowledge and action. And then the challenges of communicating that, how we tell our story. So those are key issues. We have some expertise in that and there is the whole issue of frames and what different frames there are in the climate change debate and how frames relate to political understanding and political action.* (#13: WG2 and WG3).

The participants thus drew different boundaries between being policy-relevant and policy-prescriptive. While they did not criticize other views, they maintained their own views and were confident in their demarcation. Interestingly, even those who emphasized that the IPCC is a hybrid organization in which political interests influence the assessments (not least in the Summary for Policy-makers) still did not see the IPCC as policy-prescriptive.

In addition to the challenge of how to make climate science relevant without being prescriptive, several participants emphasized the difficulty of knowing what is comprehensible and relevant to policy-makers. Many therefore welcomed the fact that the IPCC has staff (officials and communication specialists) who help to identify and formulate key messages in the assessments. Some also mentioned that it is a challenge to make the message understandable without losing or misinterpreting its scientific meaning.

All participants agreed that the IPCC has managed to be policy-relevant while not being policy-prescriptive. However, a few believed that the IPCC may face difficulties in the future because of the need for more radical policies to meet the Paris Agreement and the worsening climate situation.

> *As climate change and the climate agenda get closer to, as the pressure on it grows, there is a need to respond in more aggressive systemic ways. I mean, I think the IPCC is going to face a lot of challenges, is facing challenges in terms of how you deal with that, what sort of tone, what you talk about with the audiences.* (#13: WG2 and WG3).

So it seems that new boundaries have to be drawn, but this is nothing new for the IPCC. One characteristic of the IPCC is that it is a learning organization that has adapted to its changing environment (Beck and Siebenhüner, 2022). As one participant who has been involved with the IPCC almost since its inception said:

> *I think it reflects developments in science, which has become more multidisciplinary and more friendly toward not just incorporating sets of views from different disciplines but also looking outward at what the world really needs from it. And an internal evolution in the IPCC, where scientists are becoming more comfortable making judgments that 20 years ago they would have shit their pants if they had to make. It's changing the culture inside, and there's a change in the interaction between the culture and the outside world, and it's all for the better.* (#10: WG1 and WG2).

Thus, the boundary between relevance and prescriptiveness is not a fixed one, but has gradually changed without any discussion or decision.

3.4 Making uncertain knowledge useable

The participants had different views on the level of uncertainty surrounding climate change. One view was that the knowledge was sufficiently certain, and that the assessments simply showed facts and trends that were well established and increasing in certainty. Another view was that much of the assessed knowledge was uncertain. Various reasons were given for this. It could be that the models used by the IPCC were inadequate, or that there were too few observations to be able to make a particular claim with certainty. But one of the most common reasons was that the more specific you get, the greater the uncertainty.

> *Greenhouse gases trap radiation and make earth warmer, you know, [is] indisputable. But climate change will cause an increase in precipitation over the southwestern United States between 2050 and 2080, plus or minus 30% of some number, wow, there's so much uncertainty in this that there has to be an expert judgment. And the judgment might be "I do not know enough to say anything" or it might be "well yeah, but it could be as bad as this" or "as favorable as that in the sense of too much or too little."* (#10: WG 1 and WG2).

Another source of uncertainty was the impossibility of predicting societal responses to climate change. For example, it is impossible to predict with certainty the effects of climate change on migration patterns or land use (with increasing competition for land from activities such as food production, energy crops, biodiversity protection, etc.). In this context, one participant pointed out that there is a great danger that IPCC experts will quantify risks in ways that are not scientifically legitimate. The participant formulated this as a tension between "false precision" and "robustness."

> *I understand the push to quantify stuff, it can be a nice way of synthesizing things, but you can say things with numbers that look great but are kind of meaningless, but it's false precision, you have no idea what you are talking about.* (#11: WG2).

The participant was very critical of this and saw the fact that different types of information are valued differently as the biggest source of tension in the assessment process. The participant went on to say that those who advocate quantifying the probability of outcomes often claim—without any scientific basis—that this is what influences decision making. They have never worked in the political arena and have no scientific knowledge of what influences decision-making, yet they argue strongly for this unfounded position.

> *It's like "What's the sexy number that we can throw out there that someone will actually understand?" And that's what gets communicated. Meanwhile these are super highly uncertain. /…/ There's a whole bunch of other things you could communicate in a very robust way that did not get communicated because it could not be quantified in terms of numbers. So, I think it's an internal problem, but it's also an external problem, in terms of how we communicate more broadly to the public about climate change and what all the science actually means.* (#11: WG2).

Several of the participants highlighted the IPCC's uncertainty analysis as extremely important.[1] It is a "brilliant innovation" and represents "major progress," as two participants put it. According to them, this framework has acquired a crucial external function: it has enabled the IPCC to formulate and communicate knowledge to decision-makers, even when this knowledge is fraught with uncertainty.

> *Whereas for something else it allows us to make an assertion, "the evidence shows that," and then you can say whether it's definitive evidence or a bit more speculative. So, I think the use of confidence limits is a very, very important thing both for the science community and for the policy community.* (#18: WG 1 and WG2).

It also played an important internal role in bridging the gap when experts made different assessments:

> *Now, among scientists themselves there is always a debate about how you phrase something, some scientists would really like to have very strong statements, others would say "I think we should say it in a much softer way." Now, one thing that helps a lot is to include confidence statements.* (#18: WG1 and WG2).

One participant said that it could also be used functionally in the assessment, as a means of reaching consensus on the state of knowledge.

> *If you are not happy, we have to reduce the confidence level of our statement.* (#4: WG2).

Thus, the IPCC's uncertainty analysis has not only an external, but also an internal function: to bridge the gaps between different positions.

The boundary between certain and uncertain knowledge is crucial for the IPCC, and the organization has devoted much time to developing its uncertainty framework (Reisinger et al., 2020). The proponents of quantification see it as a way to make science pure and influence policy-making, whereas its critics see it as a polluted practice, caused either by overly broad scientific ideals of quantification or by a strategy for maximizing the political influence of science.

3.5 The IPCC as a consensus-builder

Some participants emphasized the importance of consensus. They did so not primarily because it is something that characterizes science, but rather as a means of gaining political influence. Some even saw consensus as unscientific, something that exists only to facilitate political decision-making.

> *In some ways, I think my view of what the IPCC does has changed, so on the face of it, and according to its principles of association, the IPCC is about synthesizing scientific evidence and presenting it in a way that is acceptable to policy-makers. In practice, however, the IPCC is really an organization that is about trying to build the consensus from a very diverse range of groups. And so a lot of the elements that the IPCC follows are essentially about what is required to try and build an effective consensus, nothing to do with the science.* (#7: WG3).

Interestingly, the participant emphasized that, from a policy perspective, it is not the report that is important, but the processes that lead to a global consensus.

> *I mean, the IPCC is ultimately a consensus engine, it's a process that is run through partly to produce reports, but the reports are almost incidental to the building of a global consensus around the evidence of particular climate impacts or artifacts and the evidence about what you might do about them.* (#7: WG3).

The participants stressed that scientists generally hold very different views about how to translate science into policy advice and, not least, on what should be done. The IPCC brings all these scientists together and facilitates a cross-disciplinary conversation about the issue. This is an important and unique role of the IPCC.

In addition, the participants emphasized that by being part of the assessment process, the IPCC experts are better equipped to urge their own governments to take action, in terms of both having a better understanding of what makes knowledge policy-relevant, and of being able to speak and act nationally with the authority of a global consensus on climate change.

The participants placed consensus on the political side of the boundary between science and policy. It is a means by which science can influence policy. At the same time, this point of view can be problematized, as some participants, when discussing the inclusion of the social sciences in the IPCC, found it problematic that, unlike the natural sciences, the social sciences often arrive at divergent positions that are difficult to synthesize and therefore difficult to use in developing policy recommendations.

4 Discussion

How, then, does the IPCC navigate the complex political and scientific landscape in which it seeks to mobilize science into a scientifically legitimate and politically relevant voice? As the analysis above shows, although there are different internal positions and the IPCC experts draw different boundaries, the IPCC has nevertheless managed to speak with one voice in its knowledge assessments. Some important conclusions can be drawn from the empirical analysis, but the results should be interpreted with some caution. Although the empirical analysis is based on experts with a wide range of experience (see Supplementary material), the number of experts interviewed is still limited.

First, boundaries are drawn not only externally, in terms of how the IPCC orients itself to and communicates with its organizational environment, but also internally, within the organization. Experts from different disciplines and research traditions meet, and different

1 The IPCC uncertainty framework, originally from 2010, is based on scientific agreement (low-medium-high) and the evidence base (limited-medium-robust), which together constitute a confidence matrix. The framework also includes a likelihood scale based on quantitative, probabilistic assessments of uncertainty, which are then communicated in terms of qualitative statements (10 categories, from virtually certain to exceptionally unlikely) (IPCC, 2010; for an analysis of the IPCC uncertainty framework, see Janzwood, 2020).

opinions compete to best explain what characterizes scientific knowledge and how it can be made understandable, credible, and policy-relevant. This means that while the IPCC has a clear and explicit view (front stage), there is an ongoing internal debate (backstage) about where to set the boundaries in the practical work of assessing and synthesizing research.

In this case, the participants drew their lines in order to delineate the boundaries of science (for some, to make it unpolluted), but also in order to make it useful (which for some means that it is polluted, involving values and political considerations). There were a variety of different understandings of both what constitutes scientific knowledge and what is needed for scientific knowledge to be relevant and useful to decision-makers. Much of the discussion about boundaries concerns the appropriate trade-off between doing justice to science (preserving its complexity) and making it understandable and useful (making it relevant to policy-makers). However, as the empirical analysis shows, a wide variety of boundaries are drawn, and there is considerable disagreement about where they should be drawn, based on different views of what science is and how it can be made politically useful. Interestingly, among those who saw the IPCC as a boundary organization, the fact that the IPCC takes political considerations into account was not a problem, but rather a strength, as long as it avoided making policy prescriptions.

Second, a crucial boundary is that between policy-relevance and policy-prescriptiveness. All participants stressed the importance of the IPCC being policy-relevant without losing its epistemic authority, and none questioned the IPCC's public mantra of being "policy-relevant and yet policy-neutral, never policy-prescriptive." However, they draw this boundary somewhat differently, mostly by linking it to policy frameworks and established (adopted) policies (such as the Paris Agreement and Agenda 2030). By linking policy-relevance to current political frameworks and politically determined goals, the experts perceived their knowledge assessments and recommendations as policy-relevant but unpolluted by policy prescriptions. At the same time, as mentioned above, several participants touched on the political sensitivity of the work, even claiming to avoid discussing questions of responsibility and making demands on specific actors.

Third, the boundary between certain and uncertain knowledge is ambiguous. All participants consider this boundary to be important, but they disagree on where to draw it. Some argued that the assessments should include only established facts and trends, which in practice means quantified knowledge that can be aggregated (and often included in modeling). Others argued that this limited view of science does not do justice to forms of contextual and non-quantitative knowledge that are highly relevant to policy-makers, and that the IPCC needs to be redesigned to better incorporate this kind of knowledge into its assessments. Not least, knowledge about societal responses to climate change will never fit into this limited understanding of scientific certainty. It should also be noted that many of participants appreciated the IPCC's structured model for dealing with scientific uncertainty (Janzwood, 2020; Reisinger et al., 2020), in which experts are tasked with assessing the evidence for a claim as well as its scientific agreement. The participants see this as an important innovation that enables the IPCC to develop policy-relevant knowledge even in areas of scientific uncertainty and scientific disagreement.

Fourth, it also shows that the boundaries drawn by the participants did not primarily function to delegitimize certain knowledge claims, but rather the opposite: by drawing different boundaries, quite different views on the relationship between science and policy and on the character of the IPCC could co-exist without destabilizing the IPCC. As seen above, there is some criticism of the IPCC among the participants, but not to the extent that any of them would hesitate to continue their involvement with the organization. They all agree on the importance of drawing boundaries between science and policy, between relevance and prescriptiveness, and between certain and uncertain knowledge—but they have different ideas about where these boundaries should be drawn or what these determinations mean. In this sense, the IPCC has managed to deal constructively with various internal demands; the experts may differ in their positions but still agree that certain boundaries are important. In this way, the IPCC can accommodate different positions internally while maintaining a unified position externally.

Finally, what does this study contribute to the question of how the IPCC can better inform climate policy? There is an ongoing scientific debate about how to make science useful (see, e.g., Bamzai-Dodson et al., 2024; Jagannathan et al., 2023; Lucas, 2021a, 2021b; White and Lidskog, 2023). The normative purpose underlying this debate is that science should influence decision-making by identifying options for action, assessing their consequences, and sometimes suggesting which option to choose or providing new ways of framing and staging an issue so that it can be understood in a new way (Castree et al., 2021; Lidskog et al., 2022; Paterson, 2021). At the same time, it is a challenge to navigate a landscape of divergent beliefs about what constitutes policy-relevant science, sometimes questioning the scientific character of this knowledge and sometimes questioning its policy-relevance. This challenge concerns both external and internal legitimacy; the demands of policy-makers and stakeholders, as well as those of the scientific community and the IPCC experts, must all be met.

The IPCC must evolve to be both epistemically authoritative and politically relevant. While determining the IPCC's impact on climate policy is a complicated matter (Grundmann, 2006; De Pryck, 2018), it is not too bold to argue that the IPCC has been extremely important for climate policy, not least in terms of stabilizing and disseminating global knowledge about climate change. Its current way of working—its institutional design and its adaptation to changing external conditions—has been successful in putting the issue of climate change on the international policy agenda (Bhandari, 2020; Beck and Siebenhüner, 2022). However, the current changing environmental and political context is likely to place new and greater demands on the IPCC (Lidskog and Sundqvist, 2022a). Global society has not yet succeeded in bending the global emissions curve, and countries are struggling to meet the Paris Agreement's goal of reducing emissions by 2030 (Stoddard et al., 2021). Increasingly strong and far-reaching policies will be needed to avoid a drastic rise in the global temperature. In this situation, it is likely that the IPCC will face growing demands to assess literature and make recommendations that are relevant to countries working to transform their societies. This was also emphasized by some of the participants, who said that the most important task for the IPCC today is to develop policy-relevant science on what societies can and should do to limit global warming and adapt to the changing climate.

This is consistent with other studies showing that to support more far-reaching climate policies, the IPCC needs to interact better with its users (Kirchoff et al., 2013), incorporate more information on

possible policy choices (Petersen, 2022), and develop better strategies (Hermansen et al., 2021), including a wider range of scenarios (Mahony, 2022) and deeper knowledge of the mechanisms of social change at different spatial and temporal scales (Lidskog and Sundqvist, 2022b). This may also mean that the IPCC needs to consider whether it is institutional design and practices for assessing and synthesizing knowledge are optimal (Asayama et al., 2023; Hermansen et al., 2023; Rantala et al., 2024).

However, the IPCC has focused primarily on generating knowledge about physical parameters at the global scale, and has given much less priority to the social, political, cultural, economic and ethical aspects of climate change (Grundmann, 2024). Greater attention to these aspects of climate change is needed to develop actionable knowledge for more far-reaching climate policies.

The IPCC has demonstrated that it is a learning organization that has adapted to its changing context, as well as to questioning and criticism, throughout its history. However, as Beck and Siebenhüner (2022) show in their evaluation, the IPCC has mainly made incremental adjustments and partial improvements ("adaptive learning") rather than transforming its conceptual frames and values, its objectives and main practices ("reflexive learning"). Events, external evaluations, and scientific criticism have pointed to the need to explore structural changes in its institutional arrangements and working methods, but these opportunities for more far-reaching organizational change have not yet been exploited.

Regardless of how the IPCC adapts to the changing context and the expert position it occupies, it needs to reflect on its current ways of organizing, conducting, and communicating its assessments. If it fails to do so, there is a risk that what it considers to be policy-relevant and useful knowledge will differ from what decision-makers need.

Data availability statement

The datasets presented in this article are not publicly available due to the privacy issues relating to the interview materials. Requests to access the datasets should be directed to rolf.lidskog@oru.se.

Ethics statement

Ethical review and approval were not required for the study on human participants in accordance with the national legislation and institutional requirements (according to Swedish legislation, ethical review is only demanded for studies involving personal sensitive information. This interview study does not cover any personal sensitive information). The studies were conducted in accordance with the local legislation and institutional requirements.

Author contributions

RL: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Validation, Writing – original draft, Writing – review & editing.

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fclim.2024.1408513/full#supplementary-material

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