Three institutional pathways to envision the future of the IPCC

Asayama, Shinichiro; De Pryck, Kari; Beck, Silke; Cointe, Béatrice; Edwards, Paul N.; Guillemot, Hélène; Gustafsson, Karin M.; Hartz, Friederike; Hughes, Hannah; Lahn, Bård; Leclerc, Olivier; Lidskog, Rolf; Livingston, Jasmine E.; Lorenzoni, Irene [**and 16 more**]

How to cite

ASAYAMA, Shinichiro et al. Three institutional pathways to envision the future of the IPCC. In: Nature climate change, 2023, vol. 13, n° 9, p. 877–880. doi: 10.1038/s41558-023-01780-8

This publication URL: https://archive-ouverte.unige.ch/unige:172607
Publication DOI: 10.1038/s41558-023-01780-8

Three institutional pathways to envision the future of the IPCC

Shinichiro Asayama, Kari De Pryck, Silke Beck, Béatrice Cointe, Paul N. Edwards, Hélène Guillemot, Karin M. Gustafsson, Friederike Hartz, Hannah Hughes, Bård Lahn, Olivier Leclerc, Rolf Lidskog, Jasmine E. Livingston, Irene Lorenzoni, Joanna Petrasek MacDonald, Martin Mahony, Jean Carlos Hochsprung Miguel, Marko Monteiro, Jessica O'Reilly, Warren Pearce, Arthur Petersen, Bernd Siebenhüner, Tora Skodvin, Adam Standring, Göran Sundqvist, Renzo Taddei, Bianca van Bavel, Mark Vardy, Yulia Yamineva and Mike Hulme

The IPCC has been successful at building its scientific authority but it will require institutional reform for staying relevant to new and changing political contexts. Exploring a range of alternative future pathways for the IPCC can help guide crucial decisions about redefining its purpose.

With the release of its Synthesis Report in March 2023, the IPCC concluded its Sixth Assessment Report (AR6)—its busiest, longest, and perhaps most challenging cycle given the major disruptions caused by the COVID-19 pandemic. The IPCC will soon commence its Seventh Assessment Report (AR7) cycle, beginning with the election of the new Bureau in July 2023. As with previous assessment cycles, this is a moment to rethink the work of the institution and discuss how it can be reformed to remain fit for purpose [1].

At the beginning of the AR6 cycle in 2015, the incoming chair, Hoesung Lee, stated his ambition for the IPCC to take a 'solution turn', shifting its focus from assessing the scientific basis of climate change to offering a range of policy solutions [2]. After July, the new chair of the IPCC will also have important choices to make in guiding its future direction during the AR7 cycle.

There has been no shortage of previous proposals for reforming the IPCC [3, 4]. These have reflected different expectations for the role the IPCC should play in the complex web connecting science with policy and how it can best serve decision-makers. Due to institutional constraints, however, these proposals usually end up as a wish list. Structural inertia and power asymmetry within the IPCC make it hard to imagine the institution structured in radically different ways from its current form. Nevertheless, its 35 years of existence teach us that the IPCC's success hinges on its capacity to adapt its practices and procedures to changing political contexts and demands [5].

A critical decade of climate action awaits a new opportunity for IPCC reform. To avoid a situation in which its reports become out of date or not relevant to policy action by the time they are published, the IPCC needs to find ways to respond effectively to the rhythm of politics and help catalyse social change.

Here, we present three possible pathways for the future of the IPCC as it confronts new challenges that lie ahead. Whichever pathway is pursued, it will be faced with the challenge of maintaining scientific authority while pursuing policy relevance.

Five institutional pillars

The IPCC offers the most authoritative source of consolidated knowledge on climate change. Its success inspired the establishment of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) in 2012 and it is often seen as a 'gold standard' for global scientific assessment. There are frequent calls to create IPCC-like assessment bodies for issues such as artificial intelligence [6].

This success was not assured when the IPCC was established in 1988. Its own history is filled with numerous controversies and frequent challenges to its credibility and legitimacy. In its first few assessment cycles, the IPCC gained its authority by carefully adapting its mandate to changing policy needs, managing the expectations of different audiences and responding to the rapidly evolving science and media landscape [7].

Drawing upon our recent collective work critically assessing the IPCC [5], we argue that the IPCC's authority rests on five institutional pillars: (1) comprehensive assessment; (2) policy neutrality; (3) diverse participation; (4) rigorous procedure; and (5) governmental ownership (**Table 1**). These have become the institutional backbone of the IPCC that structures its epistemic and diplomatic culture [8].

The IPCC's authority is also conditional on it being a 'learning organisation', able to adapt to changing social and political contexts. In each assessment cycle, the IPCC has reflected on its work and structure and this internal evaluation serves as a guide for its institutional learning. However, this learning by the IPCC has so far remained largely incremental rather than transformational.

For example, early in 2010, the IPCC was faced with an 'institutional crisis' caused by public criticism over errors in its Fourth Assessment Report (AR4) and a full external evaluation of its procedure was conducted by the InterAcademy Council (IAC). This could have been a 'constitutional moment' for the IPCC to revisit and redefine its mandate, assessment framework and institutional arrangements (ref. [5], Ch. 6). In response to the IAC recommendations, the IPCC did strengthen its rules of procedure, for example by improving the standardisation of uncertainty language and adopting a conflict-of-interest policy (ref. [5], Ch. 3). This helped the IPCC survive the crisis and retain its authority. And yet the IPCC missed an opportunity for more fundamental change.

The IPCC's tendency to incremental change is largely because every decision about its mandate, structure and work programme must be agreed upon by all member governments. For example, discussions at the 57th plenary session held in September 2022 raised the question of potential reforms to its structure for the next cycle [9]. Despite bold suggestions from Bureau members and a strong appetite among many governments and observers for reforming the organisation, no convergence of views emerged because a few governments favoured the status quo, expressing their satisfaction with its current structure.

This does not mean that the IPCC is doomed never to escape its past, but overcoming this structural bias to incrementalism is not easy. It requires pressure from inside and outside, going beyond conventional thinking to imagine alternative pathways toward more radical change.

Three future pathways

The coming decade brings new challenges to the IPCC. It will come under growing political pressure to inform the climate solution space [10]. The IPCC is expected to support the implementation of the Paris Agreement and in particular its periodic global stocktakes, the first round of which will close in 2023. If the IPCC aims to align its assessment cycle with each stocktake cycle, the current seven-year cycle will have to be cut short. This will place a significant burden on its assessment process, but might be necessary if the IPCC wants to strive for policy relevance.

To envision the future of the IPCC, it is useful to explore a range of alternative futures of the IPCC operating under a new mandate and with different structures. An exploration of such alternative futures can help stimulate the broader public debate about what kind of change is needed for the IPCC to enhance the science-policy interface.

In IPCC assessments, scenarios are used to explore a wide range of alternative future pathways of climate and development under different assumptions [11]. This scenario approach to

future thinking is also applicable to envisioning its own future. Here, we present three speculative scenarios for reforming the IPCC: (1) *"Building on Success"*; (2) *"Diversifying Viewpoints"*; and (3) *"Advocating for Change"* (**Table 2**). The latter two scenarios might be less likely to be realised due to structural inertia within the IPCC, yet articulating them helps to clarify some of the pathways the IPCC could alternatively follow.

These scenarios each make different assumptions about the five key institutional pillars (**Table 1**). Each scenario therefore has different conceptions of where the credibility and legitimacy of the IPCC will come from—either from a continued striving for neutrality, a stronger emphasis on diversity, or an explicit recognition of responsibility. However, the role of social sciences and humanities in the assessment remains an open issue across all scenarios (see **Box 1**).

The characteristics of the IPCC in each scenario (**Table 2**, point c) can be described by different approaches to climate knowledge and three ideal types of science advice in policy [12]: a 'science-first' approach and a 'science arbiter' (*Building on Success*); a 'cosmopolitan' approach and an 'honest broker' (*Diversifying Viewpoints*); and a 'transformative' approach and an 'issue advocate' (*Advocating for Change*).

It must be noted that there is no 'right way' for reforming the IPCC. Each scenario poses new kinds of political challenges to the IPCC, which might undermine the public perceptions of its authoritative status or policy relevance. These scenarios offer some light on the challenges that the IPCC will face when seeking to keep a delicate balance between retaining scientific authority and pursuing policy relevance.

A fork in the road

The institutional life of the IPCC has been and will continue to be shaped by changing politics and cultural shifts in societies. This embeddedness of the IPCC's existence can be portrayed using the metaphor of 'a ship on the ocean'—a ship that is set afloat and that navigates an ocean with dynamic currents by regularly adapting its sailing techniques and finding new pathways on a sea chart. This metaphor suggests that the IPCC (the ship) cannot be isolated from the wider social and political context in which it evolves (the ocean). It also tells us that changing ocean dynamics may need a new ship design.

The success of the IPCC has led to a situation in which it is increasingly called upon to meet a growing number of diverging expectations from different audiences. But the IPCC cannot be all things for all people. This is because of its limited human resources and institutional capacity, but also because of competing worldviews on the role of the IPCC, namely, an unresolvable conflict between conducting neutral assessments and engaging in policy advocacy and the incommensurability of reaching consensus among different value systems and knowledges. Regardless of the future pathway that the IPCC takes, these trade-offs are impossible to ignore.

References

1. Carraro, C. et al. *Science* **350**, 34–35 (2015).
2. Lee, H. *Science* **350**, 1007 (2015).
3. Hulme, M., Zorita, E., Stocker, T.F., Price, J. & Christy, J.R. *Nature* **463**, 730–732 (2010).
4. Stocker, T.F. & Plattner, G.-K. *Nature* **513**, 163–165 (2014).
5. De Pryck, K. & Hulme, M. *A Critical Assessment of the Intergovernmental Panel on Climate Change*. (Cambridge Univ. Press, 2022).
6. Bak-Coleman, J. et al. *Nature* **617**, 462–464 (2023).
7. De Pryck, K. *Glob. Policy* **12**, 80–89 (2021).
8. Borie, M., Mahony, M., Obermeister, N. & Hulme, M. *Glob. Environ. Change* **68**, 102261 (2021).

9. *Earth Negotiations Bulletin – Summary of the 57th Session of the Intergovernmental Panel on Climate Change*. (IISD, 2022); https://enb.iisd.org/57th-session-intergovernmental-panel-climate-change-ipcc-57-summary
10. Schipper, E.L.F., Dubash, N.K. & Mulugetta, Y. *Clim. Change* **168**, 18 (2021).
11. Chen, D. et al. in *Climate Change 2021: The Physical Science Basis* (eds. Masson-Delmotte, V. et al.) Ch. 1, 147–286 (IPCC, Cambridge Univ. Press, 2021).
12. Pielke, R.A. *The Honest Broker: Making Sense of Science in Policy and Politics*. (Cambridge Univ. Press, 2007).
13. Klinsky, S. et al. *Glob. Environ. Change* **44**, 170–173 (2017).
14. Jebeile, J. *Soc. Epistemol.* **34**, 453-468 (2020).
15. Raman, S. & Pearce, W. *WIREs Clim. Change* **11**, e672 (2020).
16. Beck, S., Forsyth, T. & Mahony, M. *One Earth* **5**, 586–588 (2022).
17. Hartz, F. *WIREs Clim. Change* **14**, e814 (2023).
18. Fazey, I. et al. *Energy Res. Soc. Sci.* **40**, 54–70 (2018).
19. O'Neill, S.J., Hulme, M., Turnpenny, J. & Screen, J.A. *Bull. Am. Meteorol. Soc.* **91**, 997–1002 (2010).
20. Victor, D.G. *Nature* **520**, 27–29 (2015).

Acknowledgements

This work partly originates from a workshop organised by National Institute for Environmental Studies in April 2023, where S.A., K.D.P. and M.H. participated. S.A. acknowledges the financial support from the Japan Society for the Promotion of Science, Grants-in-Aid for Early-Career Scientists [20K20022]. M.H. acknowledges the financial support from the Department of Geography, University of Cambridge.

158 **Table 1. Five institutional pillars of the IPCC's authority**

Institutional pillar	Description
Comprehensive assessment	The IPCC's mandate is to conduct comprehensive assessments of the scientific literature on the scientific basis of the risk of human-induced climate change, its potential impacts and options for adaptation and mitigation. This mandate serves as the basis of its institutional structure with three independent Working Groups (WGs). Thousand-pages-long comprehensive Assessment Reports (ARs) and dedicated Special Reports (SRs) on specific issues are key products of the IPCC and the embodiment of its scientific credibility.
Policy neutrality	Since its inception, the IPCC's work has been governed by the principle of 'policy relevant but not policy prescriptive'. This neutrality principle is considered by the Panel of central importance to maintaining its credibility and legitimacy, and to securing public trust. Any statement by the IPCC that is perceived to be prescriptive could be accused of breaching this principle and of therefore undermining its authority. The guise of policy neutrality thus acts as a 'firewall' to protect the IPCC against such criticisms.
Diverse participation	From its early days, the IPCC has sought to facilitate the involvement of developing countries by financially supporting their participation as authors or government representatives. The IPCC has expressed an increasingly strong desire to secure diverse representation among its authors across expertise, gender, geography and experience. More recently, for the purpose of capacity-building, it has also promoted the inclusion of early-career researchers. Although meaningful participation from developing countries is mixed and uneven, advancing diversity is considered essential to the legitimacy of the IPCC as the voice of global climate knowledge.
Rigorous procedure	Clear, meticulously defined rules of procedure are widely regarded as a bedrock of the credibility of the IPCC. In responding to criticisms, the IPCC has routinely strengthened its assessment procedures to enhance the robustness of its reports. The highlight of this process is a two-tier peer review, both by experts outside the IPCC and by government representatives. An extensive, open and transparent review of the scientific literature underlies the scientific rigour of its assessment. The IPCC also takes great care in calibrating the use of uncertainty language to communicate the main conclusions of its report.
Governmental ownership	The IPCC is governed by its member states who contribute to the assessment process by electing members of the Bureau, approving the report outline, nominating authors, and approving the reports' Summaries for Policymakers (SPMs). The line-by-line approval of SPMs is a unique institutional feature of the IPCC. While this gives state governments considerable influence over its work, it is widely recognised as a key mechanism for ensuring the IPCC's legitimacy and generating a shared ownership of its report.

159 Note: The description of five institutional pillars is based on the relevant chapters (Ch. 3, 5, 6, 7, 8, 9,
160 10, 11, 12, 13, 17, 20 and 21) in ref. [5].
161

162 **Table 2. Three scenarios of future pathways for reforming the IPCC**

Scenario	Description of underlying logic (a), institutional form (b), main characteristics and challenges (c)
Building on Success	(a) This is what some may call a 'business as usual' scenario. It assumes that the IPCC is an already well-functioning institution. By reason of past successful experience, it is considered to be able to retain its scientific authority by adapting to new political demands without major institutional reform. (b) While there are some minor reforms in its assessment framework or work programme, the institutional structure largely remains intact. The IPCC continues to put a high priority on comprehensive ARs and SRs produced by the three existing WGs. It preserves policy neutrality as its governing principle, with a focus on communicating consensual and universal statements. It also continues to commit to improving (though, incrementally and instrumentally) the disciplinary, regional and gender balance in all aspects of its work, as well as to involving more early-career researchers. No major procedural change is introduced to the review process. The approval of SPMs follows current diplomatic practices, leaving government representatives with substantial influence over its outcome. (c) Overall, this scenario is characterised by the institutional form that favours the status quo, inherited from past configurations. It is beneficial for those who already have established tenure within the institution, but it perpetuates uneven participation and knowledge hierarchy with marginal engagement in social sciences and humanities. This is called a 'science-first' approach to climate knowledge, taking the role of a 'science arbiter' that answers a specific policy question. The major challenge for this scenario is the growing policy irrelevance of the IPCC's mega-assessments. In this crucial decade for action, a large comprehensive assessment published every seven or more years is of little use for policymaking.
Diversifying Viewpoints	(a) This scenario assumes that the IPCC recognises the need to reflect different social values in its assessment for providing policy-relevant knowledge to a wide range of stakeholders and rights holders. As the issues of equity and justice are of growing political significance [13], the pursuit of diversity, equity and inclusion (DEI) is understood as fundamental for its credibility. (b) While the mandate of comprehensive review and the three WGs structure remain unchanged, DEI is espoused as a new governing principle in tandem with policy neutrality. The IPCC expresses a strong commitment to fostering greater inclusion of experts from diverse backgrounds across age, gender, race, religion, socioeconomic status and region. It also introduces procedures aimed at better incorporating social sciences and humanities, and various forms of knowledge from Indigenous communities, civil society and the private sector to promote 'epistemic equality' [14]. While governmental ownership remains key, a

	wider range of societal stakeholders is allowed to offer their own voices during SPM approvals. (c) Overall, the institutional form of the IPCC in this scenario is characterised by what is called a 'cosmopolitan' approach to climate knowledge with a strong emphasis on epistemic and ontological diversity [15]. The focus is more on agreeing to disagree than on seeking a consensus above all. Abiding by the ethos of value pluralism, the IPCC plays the role of an 'honest broker' to expand a range of policy options. The big challenge for this scenario lies in shifting away from the existing procedures of peer review and establishing new ones to better capture non-peer-reviewed, non-English and grey literature. A question is also raised about who are considered 'legitimate' stakeholders in the SPM approval and how to prevent the approval process from being dominated by a few powerful state governments and interest groups.
Advocating for Change	(a) The assumption of this scenario is that under new political circumstances, the IPCC in its current form is not fit for purpose. It therefore requires institutional transformation to guide transformational change in societies [16]. The IPCC's legitimacy is considered to rest on driving real change in policy. (b) The mandate of comprehensive assessment is no longer a priority; it rather privileges the production of SRs (or similar) on specific issues to help effective policy implementations at different levels. The WGs are dissolved and replaced by several (both standing and ad-hoc) expert groups that cover a range of policy-relevant topics and are tasked to produce reports in a nimble and timely manner. It relinquishes the neutrality principle and does not shy away from engaging in evidence-based policy advocacy by embracing social responsibility [17] as a new governing principle. It recognises diverse and inclusive participation as essential for catalysing political change. The review procedure is renewed to better integrate practical forms of knowledge based on real-world experiences. Finally, it shifts governmental ownership towards a broader ownership model in which government representatives approve the SPMs with non-governmental stakeholders on an equal footing. (c) Overall, this scenario characterises the IPCC as a 'transformative' approach to climate knowledge, directly linked to political actions [18]. The role of the IPCC becomes an 'issue advocate' for transformational and equitable change. It requires a far-reaching overhaul of its institution, redefining its purpose as responsible policy advocacy. But such institutional overhaul is a tall order. A grave challenge for this scenario is overcoming both institutional and psychological resistance from governments and experts to radical change, as well as finding common ground among diverse stakeholders for the SPM approval.

Note: The narrative description of each scenario consists of three elements: (a) the underlying logic of scenario assumptions; (b) the description of the IPCC's institutional form in scenarios; and (c) the main characteristics and challenges of scenarios.

Box 1. Social sciences and humanities in the IPCC

The IPCC has long been criticised for creating an epistemological hierarchy placing physical science at the top of the pyramid as the 'strongest' type of knowledge, largely ignoring contributions from social sciences (except economics) and humanities [19]. The dominance of physical science in the IPCC is reflected in the structure of three WGs: starting from WGI on the physical science basis to WGII on impacts, adaptation and vulnerability, and WGIII on mitigation. This structural linearity implies that advances in climate science lead to better understandings of potential impacts, which is a prerequisite for better adaptation and mitigation policies.

To respond to the narrow scope of IPCC assessments, social sciences and humanities can help pluralise epistemic viewpoints and expose the ethical, cultural and political dimensions of climate change. These are crucial for understanding what drives or obstructs effective adaptation and mitigation action [10].

To more explicitly recognise the social science and humanities contributions, it has been proposed to add a fourth WG on 'historical, cultural, and social contexts' [19]. While this could provide more space for such knowledge, it might also perpetuate the division between WGs and further increase bureaucratic bungling. A better integration of social sciences and humanities needs to come with a recognition of the uneven distribution of capacities across regions and of the inherent worldviews underpinning such knowledge.

Also, tight governmental oversight allows only politically non-controversial statements to make it through the SPM approval [20]. Without major reform to loosen government control over its assessment process, there is little room to address the most controversial policy-relevant questions within the IPCC (e.g., the governance of solar geoengineering technologies or the role of state and non-state actors in climate disinformation and obstruction).

Author information

Shinichiro Asayama [1, *] https://orcid.org/0000-0001-6817-3862
Kari De Pryck [2, *] https://orcid.org/0000-0002-0203-5421
Silke Beck [3] https://orcid.org/0000-0002-4157-0777
Béatrice Cointe [4] https://orcid.org/0000-0002-3647-8327
Paul N. Edwards [5] https://orcid.org/0000-0001-6228-1520
Hélène Guillemot [6] https://orcid.org/0000-0001-8776-0528
Karin M. Gustafsson [7] https://orcid.org/0000-0002-1495-8346
Friederike Hartz [8] https://orcid.org/0000-0001-8820-9500
Hannah Hughes [9] https://orcid.org/0000-0002-1771-2907
Bård Lahn [10] https://orcid.org/0000-0001-9161-9455
Olivier Leclerc [11] https://orcid.org/0000-0001-5148-7603
Rolf Lidskog [7] http://orcid.org/0000-0001-6735-0011
Jasmine E. Livingston [12] http://orcid.org/0000-0002-1851-2106
Irene Lorenzoni [13] https://orcid.org/0000-0001-8226-5755
Joanna Petrasek MacDonald [14] http://orcid.org/0009-0005-1092-8210
Martin Mahony [13] https://orcid.org/0000-0002-6377-413X
Jean Carlos Hochsprung Miguel [15] https://orcid.org/0000-0001-5273-029X
Marko Monteiro [15] https://orcid.org/0000-0003-4008-4985
Jessica O'Reilly [16] https://orcid.org/0000-0002-0281-5903
Warren Pearce [17] https://orcid.org/0000-0001-6884-3854
Arthur Petersen [18] https://orcid.org/0000-0003-0706-5635
Bernd Siebenhüner [19, 20] https://orcid.org/0000-0002-0444-5889
Tora Skodvin [21] https://orcid.org/0000-0001-6673-5016
Adam Standring [22, 7] https://orcid.org/0000-0003-3477-6811
Göran Sundqvist [23] https://orcid.org/0000-0001-8120-1629
Renzo Taddei [24] https://orcid.org/0000-0002-9935-6183
Bianca van Bavel [25, 26] https://orcid.org/0000-0001-9338-4602
Mark Vardy [27] https://orcid.org/0000-0003-4008-3755
Yulia Yamineva [28] https://orcid.org/0000-0001-8360-0615
Mike Hulme [8, *] https://orcid.org/0000-0002-1273-7662

1. National Institute for Environmental Studies, Tsukuba, Japan
2. Institute for Environmental Sciences (ISE), University of Geneva, Geneva, Switzerland
3. Department of Science, Technology and Society, School of Social Sciences and Technology, Technical University of Munich, Munich, Germany
4. Centre for the Sociology of Innovation (CSI), Mines Paris, PSL University, i3 CNRS (UMR 9217), Paris, France
5. Center for International Security and Cooperation, Stanford University, Stanford, CA, USA
6. Centre Alexandre Koyré, CNRS, Aubervilliers, France
7. Environmental Sociology Section, School of Humanities, Educational and Social Sciences, Örebro University, Örebro, Sweden
8. Department of Geography, University of Cambridge, Cambridge, UK
9. International Politics Department, Aberystwyth University, Aberystwyth, UK

10. TIK Centre for Technology, Innovation and Culture, University of Oslo, Oslo, Norway
11. Centre de Théorie et Analyse du Droit (UMR 7074 CTAD), CNRS, Université Paris Nanterre, Ecole Normale Supérieure – PSL, Nanterre, France
12. Copernicus Institute of Sustainable Development, Utrecht University, Utrecht, the Netherlands
13. School of Environmental Sciences, University of East Anglia, Norwich, UK
14. Joanna Petrasek MacDonald Consulting, Ottawa, ON, Canada
15. Institute of Geosciences, Department of Science and Technology Policy, State University of Campinas, São Paulo, Brazil
16. Department of International Studies, Hamilton Lugar School of Global and International Studies, Indiana University Bloomington, Bloomington, IN, USA
17. iHuman, Department of Sociological Studies, University of Sheffield, Sheffield, UK
18. Department of Science, Technology, Engineering and Public Policy, University College London, London, UK
19. Ecological Economics Group, Carl von Ossietzky University of Oldenburg, Oldenburg, Germany
20. Department of Development Studies, Nelson Mandela University, Gqeberha, South Africa
21. Department of Political Science, University of Oslo, Oslo, Norway
22. Centre for Urban Research on Austerity, De Montfort University, Leicester, UK
23. Department of Sociology and Work Science, University of Gothenburg, Gothenburg, Sweden
24. Institute of Oceanic Sciences, Federal University of São Paulo, São Paulo, Brazil
25. School of Geography, University College Dublin, Dublin, Ireland
26. Priestley Centre for Climate Futures, University of Leeds, Leeds, UK
27. Criminology Department, Kwantlen Polytechnic University, Surrey, BC, Canada
28. Centre for Climate Change, Energy and Environmental Law, University of Eastern Finland, Joensuu, Finland

* Corresponding authors:
asayama.shinichiro@nies.go.jp (Shinichiro Asayama);
kari.depryck@unige.ch (Kari De Pryck);
mh903@cam.ac.uk (Mike Hulme)

Competing interests

The authors declare no competing interests.