Climate change and STS

Silke Beck
Professor for Sociology of Science and Technology
TU Munich
silke.beck@tum.de
https://orcid.org/0000-0002-4157-0777

Tim Forsyth
Professor of Environment and Development
London School of Economics and Political Science
t.j.forsyth@lse.ac.uk
https://orcid.org/0000-0001-7227-9475

Martin Mahony
Lecturer in Human Geography
University of East Anglia
M.Mahony@uea.ac.uk
https://orcid.org/0000-0002-6377-413X

in:

Elgar Encyclopedia of Science and Technology Studies

Edited by Ulrike Felt and Alan Irwin

Publication Date: October 2024 ISBN: 978 1 80037 798 1 Extent: 642 pp

Abstract

STS research on climate change seeks to show the historic and contemporary influences on ways of knowing climate change, and how these then shape possible solutions. STS analysis also considers ways to enhance climate science and policy by making these influences more transparent, inclusive, and open to governance. This summary focuses especially on the significance of historic framings and knowledge infrastructures that control how we know climate change; the co-production of ideas about climate risk and adaptation; the tacit social values in projections about climate change; and opportunities for democratizing climate science and expert organizations.

Keywords: Climate change, expert bodies, environmental policy, modelling, knowledge infrastructures, democratization

Climate change and the pivotal role of science

Human-induced climate change is one of the defining crises of the 21st century. It is also underpinned by science and calls to follow science. When the teenage activist Greta Thunberg spoke to the United States House of Representatives, she said: "I am submitting this report as my testimony because I don't want you to listen to me, I want you to listen to the scientists. I want you to unite behind science. And then I want you to take real action."

Climate change is an example of how science shapes collective consciousness of risks and inspires political action. But it is also a case of scientific debate functioning as a "proxy" for political debate. Disputes over policy become disputes over the veracity of science. Both "sides" of the climate controversy – mainstream scientists, as represented by the Intergovernmental Panel on Climate Change (IPCC), and climate change deniers – often act symmetrically as if climate policy will be decided by science alone. In turn, "the science" is often used to justify behavioral or political choices. Factual controversies about climate change are increasingly entangled in disagreements about competing ways of life (Latour, 2018).

In this entry, we demonstrate how concepts and debates in STS can help explain climate change and inspire democratic politics. STS research on climate change is diverse, mirroring STS approaches in general, and includes the analysis of agnolotogy (or cultivated ignorance about climate science), actor-networks and assemblages, and governmentality. This entry mainly presents findings from a co-productionist perspective, relating to co-production, civic epistemologies, and sociotechnical imaginaries. We argue these insights strengthen climate change policy because they seek ways to make science and policy more inclusive yet also self-aware. The entry starts by discussing the representation of climate change within science, the challenges of identifying risk and adaptation, and then achieving successful mitigation in the future. Finally, we reflect on ways of democratizing climate science, expertise, and assessments.

How do we "know" climate change?

STS scholars study the mutual connections between social values, practices and structures and the representation of complex phenomena through science. For example, how do ways of

knowing climate change reflect historic social values, cultures and infrastructure or shape possible solutions? How do these representations become fixed, unquestioned, and made politically salient and authoritative? And what are the implications for how we understand climate change or the people and places that experience it?

Climate change, almost universally, is represented in terms of human-induced changes to the global atmospheric system arising from enhanced greenhouse gas concentrations. While these changes are now questioned only by the most ardent climate change deniers, there are still important questions about how to understand their societal causes or what they mean in terms of winners, losers, vulnerabilities, and questions of international and intergenerational justice. Referring only to "systemic" atmospheric aspects of climate change, such as gases, can sometimes blind us to why this systemic change is problematic and how it is caused.

One of the earliest controversies about climate change policy illustrated this interpretative flexibility of systemic atmospheric change. In 1990, the US-based think tank, the World Resources Institute (WRI), developed an index listing countries most responsible for climate change giving weight to fossil fuel use, current deforestation, and methane released from rice fields and livestock. Unsurprisingly, it placed Brazil, India, and China among the top six emitting countries, a finding that worried these countries as they did not expect to reduce emissions. In response, Anil Agarwal and Sunita Narain of the Centre for Science and Environment (CSE) in India argued that WRI's index failed to acknowledge important normative questions about emissions by using national allocations rather than per capita emissions, which were much smaller in developing countries. Moreover, the index treated emissions for apparent luxuries equally as basic needs such as food and shelter. Moreover, the index did not include historical rates of industrialization or deforestation and therefore failed to acknowledge that industrialized countries had been emitting for longer (Agarwal and Narain, 1991). This dispute shows how scientific representations are co-produced with different visions of social order, and how representing climate change in terms of systems and gases can hide normative dilemmas about North-South justice and about how to live (Jasanoff, 2011).

These questions have also been applied to the atmospheric models used to understand climate change or representations of the problem, such as the Hockey Stick chart that shows how global temperatures have accelerated since the mid-twentieth century. Social scientists have used the term knowledge infrastructures to refer to the combined social and technical means of

generating and ordering global knowledges. The effect of knowledge infrastructures is to make objects like the atmosphere knowable on a global scale. Historians of climate science have argued that the emergence of knowledge infrastructures during the twentieth century led to the emergence of climate science as a quantitative field linked closely to national security, and the study of climate simultaneously with new globalized forms of analysis and governance.

For example, historians of climate science have identified four key stages in the relationship between climate science and the state in the USA (Baker, 2017). First, the US Weather Bureau used meteorology to provide "weather services" such as forecasting from roughly 1890 to 1930. Second, in the 1930s and 1940s, the Second World War strengthened connections between meteorology, geophysical research, and military purposes. Third, in the 1950s and 1960s, "climate science" became a distinct field beyond meteorology, drawing on long-term statistical analysis of large regions using computers. And fourthly, from the 1970s, climate science became capable of influencing states through the generation of new and authoritative knowledge tools such as General Circulation Models that were instrumental in shaping conceptions of climate change. Paul Edwards (2010) in particular has argued that the climate knowledge infrastructure reflected the transition from sporadic sharing of knowledge between countries in the nineteenth and early twentieth centuries towards the "quasi-obligatory globalism" that occurred after the Second World War and the rise of the United Nations as an organization coordinating data collection and management. For example, the International Meteorological Organization was created in 1873, but then made part of the United Nations as the World Meteorological Organization in 1950. Other analysts argued that geophysical sciences attracted more funding than ecology or biology because they were seen to offer more mathematical precision and prospects for environmental control (e.g. through weather modification) than other disciplines.

The knowledge infrastructures for understanding climate change, therefore, reflected various processes of monitoring based on how different states generated knowledge and then established global networks to regularize and standardize these representations. Yet, STS scholars have argued that these forms of representations also enabled an expansionist form of politics by detaching specific projections based on tangible materiality, temporal immediacy, and spatial boundedness and transforming them into distant, geographically dispersed, and increasingly faraway futures (Jasanoff, 2011). Actor-network theory has been used to show how particular ways of framing the "problem" of climate change, as shaped by models and

their sociotechnical networks, have buttressed the political legitimacy of market mechanisms such as carbon trading as means of governing emissions reductions (Blok, 2010).

Authoritative global expert groups, especially the IPCC, have become the key institutional sites where framings of climate risks are communally adopted and transformed into new, collectively held and politically powerful visions of appropriate action (Beck and Mahony, 2018). STS scholars have argued that the framings of modelling have been replicated in policymaking, such as in the presentation of predicted global temperature rises between a range of 1.5-4.5°C, which acted as an "anchoring device," or stable, unquestioned assumption, circulating within negotiations because it allowed different parties to discuss their different positions while using a shared factual basis for discussions, even if this statistic was not as certain as claimed (van der Sluijs et al., 1998).

These influences on "knowing" and representing climate change also influence understanding of climate risk and adaptation, mitigation, and democratizing expertise about climate change.

What is climate risk and adaptation?

Much of the IPCC's approach to adaptation was defined in the Second Assessment Report 1996. This report defined adaptation and adaptability as the degree to which adjustments are possible in practices, processes or structures of systems to changes in climate.

However, this definition has largely been interpreted in terms of adjustments to additional greenhouse gas concentrations within the global atmospheric system. These systemic changes largely focus on the immediate impacts of additional greenhouse gases such as storms, floods, and droughts. This definition does not engage, for example, with local drivers of vulnerability, which can mean similar climatic events can have dissimilar impacts in different places. Moreover, it reinforces a policy approach that presents adaptation as an option only to the extent that mitigation policies fail. Adaptation is thus assessed as a (marginal) cost of failed mitigation. Accordingly, the impact-based systems approach has encouraged a polarization between adaptation and mitigation and the perception that "adaptation" is only a secondary response to problems that mitigation should first address.

STS scholars have discussed these challenges in different ways. First, there is a constitutional relationship between the definition of climate change as a risk and the co-production of social behaviour assumed to respond to this successfully. The idea that additional atmospheric greenhouse gas concentrations represent "risk" contains various assumptions about how different people experience those gases as a problem. Assumptions about risk therefore influence the identification and assumed reactions of so-called vulnerable people.

Second, there is a need to consider how this emphasis on "gas forcing" as a model of adaptation overlooks additional drivers of risk and potentially upholds social inequalities that contribute to vulnerability. For example, the IPCC's Fourth Assessment Report (2007) differentiated between "planned" and "autonomous" adaptation to indicate deliberate interventions to anticipate climate change and non-cognitive responses to climatic stimuli, such as adopting drought-resistant crops and technologies or diversifying economic activities. Research shows, however, that many forms of planned adaptation can address risks associated with old or unfavoured livelihoods, such as low-income agriculture, rather than assisting people to gain access to alternative livelihoods that might offer a more holistic range of development outcomes. Indeed, some authors have argued that there is now a need to distinguish between "pollutionist" or "outcome" forms of adaptation (based on responses to additional gases) to "development" or "contextual" adaptation (which consider longer-term capacity building as well as immediate protection from climatic events) (Burton, 2009). Maladaptation, therefore, might not be just poorly planned interventions, but also the product of a misaligned approach to what constitutes risk for whom (Forsyth and McDermott, 2022). Indeed, these fears have been expressed by the IPCC Working Group II, who have acknowledged the diverse contexts of risks, and cultural and behavioural aspects of decision-making beyond gas-forcing alone.

Despite these concerns, there is also evidence that gas-forced approaches to adaptation can be upheld and co-produced through wider political discussions about and the representation of climate change. One example is the widespread belief that climate change triggers violent conflict, such as in Sudan (Darfur) or Syria. STS scholars have pointed out that this alleged causality is difficult to prove but is upheld by discourse coalitions between actors such as authoritarian states and climate change activists who seek different reasons to highlight climate change as a cause rather than other political-economic factors. While these representations might add to demands to mitigate climate change, they simplify the connections between

climate change and violent conflict and reduce attention to more localized interventions that can reduce the impacts of both.

Third, STS analysts have argued that these definitions of climate risk and adaptation reflect the political and epistemic authority of the IPCC. This, in turn, also affects how new voices are identified and mobilized in order to diversify discussions of adaptation. There are tensions between globally circulating imaginaries and local, more immediate, understandings of social and material obstacles and vulnerabilities that would improve actual lives in cities and regions (Chakraborty and Sherpa, 2021). This challenge is added to by the IPCC's preferred mode of communication of seeking consensus and speaking with one voice. STS scholars have asked if this form of technical rationality is interpreted the same way in diverse settings or re-embedded in nation-specific institutional contexts (Jasanoff, 2011).

Yet democratizing adaptation is harder than it seems. Much discussion within the IPCC and sustainability science has argued for a form of "knowledge co-production" that depends on consultation with local people and other stakeholders to make adaptation more relevant to vulnerable people. STS scholars, however, have argued that co-production is a deeper and less cognitive mutual shaping of knowledge and visions of social order. This latter approach to co-production asks how representations of risk and agency reflect other values and assumptions, including who should be consulted with and for what overall objectives (Miller and Wyborn, 2018).

These potential challenges have been discussed in relation to "community-based" adaptation (CBA) as a way to localize adaptation by engaging vulnerable people and giving them equity within adaptation planning. Critics have suggested that CBA might romanticize the identity, knowledge, and agency of so-called "communities." One famous image of CBA based on women using water hyacinth plants to create floating gardens to grow vegetables during flooding in northern Bangladesh has been claimed to show successful local agency in the face of global crisis. Critics, however, suggest these images might still reinforce gendered roles, ignore the role of the state and market, and appeal more to some Westerners' ideas of appropriate risk management in poorer countries. The word "community" is often invoked in discourses of inclusion and progress but hides deep social exclusions at the local level and the challenges faced by local people in influencing change.

STS scholarship has therefore shown that discussions about adaptation often reproduce models of risk and vulnerability that can simplify how climate change poses risks to different people. Successful adaptation increasingly means seeking more diverse ways to achieving a sustainable life, rather than defining that life in terms of managing changes driven by systemic atmospheric change alone.

Climate change mitigation and the future

Climate change mitigation means reducing atmospheric greenhouse gas concentrations by either lowering the emission of greenhouse gases, or sequestering gases through activities such as tree planting. STS scholars have analysed the assumptions used to shape and predict future mitigation to highlight inherent values and assumptions (Beck and Mahony, 2018).

In particular, integrated assessment models (IAMs) have risen to prominence in climate policy and STS scholarship since the Paris Agreement (2015). These models indicate a turn in the temporality of climate politics from accounting based on historical emissions towards projecting future emissions with regard to intergenerational responsibility. The Paris Agreement set a highly ambitious goal of keeping increases in global average temperatures to no more than 1.5°C above pre-industrial levels. To attain this goal, the concept of a global net-zero future for human society has been proposed to achieve a balance between anthropogenic emissions of greenhouse gases into the atmosphere and removals by "sinks" of greenhouse gases, by the second half of this century. The Paris Agreement thus opens the door for "technological solutionism."

In particular, much debate focuses on negative emissions technologies (NETs), or technologies that remove additional greenhouse gases from the atmosphere. Recent climate models and IPCC reports have presented significant use of NETs as necessary and inevitable for reaching the goals formulated in the Paris Agreement, despite serious doubts about the scales at which such negative emissions can be achieved (Beck and Mahony, 2018). Studies show that technological solutions hold high appeal in both developed and developing countries, partly because they are seen as progressive by definition (as technological "advances") and partly because they offer pragmatic short-term actions when it might be too costly or unpopular to change routine behaviour or deep-seated institutional arrangements. This "technological

solutionism" has been criticized for the following reasons: it treats symptoms of climate change rather than underlying causes such as changes in economy and land use; and it stabilizes rather than challenges path-dependencies and material or discursive lock-ins, thus reinforcing entrenched power structures and lifestyles.

STS thinking illustrates how particular ways of knowing are built upon taken-for-granted assumptions. For instance, the choices of model priorities and parameters have been relied on and shaped by fairly techno-optimistic, optimization-based assumptions of progress, with a carbon price as the main driver. Models informing the authoritative IPCC assessments uncritically reproduced and thus also stabilized the dominant paradigm of "progress," based on the almost uncritical pursuit of perpetual economic growth, piecemeal politics, and narrow, techno-economic rationality. Re-directing the rising trajectory of emissions toward Paris-compliant rates of decarbonization, therefore, challenges mitigation based on existing assumptions about economic growth. Instead, there needs to be a shift in the type of growth too. Current discussions about future transformative change, which might seek to achieve this deeper realignment of growth, are still growing (Carton et al., 2020). But to date, worldviews and perspectives that offer alternatives to the older, constricted development pathways have tended to be marginalized, undermined, or otherwise ignored, and instead, political debate has focused on shorter-term questions of distributive impacts, who wins and who loses, and who speaks for the most vulnerable and marginalized groups within these frameworks. Perhaps, then, it is the job of STS scholars engaged with climate change to help empower alternative ways of thinking about and defining desirable collective futures (Lövbrand et al., 2015).

The emerging markets for negative emission technologies are an important site of STS scholarship (Carton et al., 2020). Relatedly, the spectre of direct solar radiation management (technologically manipulating the albedo of the entire planet in order to cool it down) has raised similar questions of how emerging global governance norms – co-produced between the realms of science and politics – may or may not sit easily with diverse "local" norms, priorities and preferences. As scientific debate increasingly recognizes the onset of the Anthropocene, a new geological epoch defined by human modification of the entire Earth-system, it becomes tempting to imagine a future where humanity takes deliberate control of global systems through new technological means like geoengineering. Emerging tensions between local and global scales of knowledge-making, local and global imaginaries of sociotechnical futures, and

different national regulatory styles have recently occupied the intersections of STS, human geography, institutional theory, and political ecology (e.g. Latour, 2018; Hulme, 2010).

STS and climate democracy

STS scholars seek to understand the changing role of experts in this new landscape. They have explored the fundamental tension between the "policy-relevance" and "political-neutrality" of science when assessing policy solutions, mapping the corridor of political action and assessing the forms of transformative change seemingly necessary to meet environmental challenges. Building on the body of STS work we have (briefly) introduced here, they have argued that the value-ladeness of solution-oriented climate change science means that remaining policy-relevant may mean abandoning the performance of political neutrality.

But how can STS scholarship engage with making democratic futures? The push towards a more democratic form of climate politics is happening across a range of spatial scales, documented in studies of how terms like "adaptation" are made and circulate through policy and public discussions; of how democratic local reckoning with climate change might be scaled up; and in work showing the multiple ways diverse publics and grassroots communities are already participating in, and driving, sustainability transitions through their own diverse framings of the problem, models of expertise, and modes of practice (Chilvers et al., 2021).

STS scholars have conducted much work to identify how the IPCC generates both knowledge and political legitimacy. Comparative STS approaches seek to address why the shared knowledge base provided by the IPCC is interpreted in different ways and what accounts for national differences in the uptake and public understanding of climate risks in different contexts. Studies have highlighted the civic epistemologies – or the national contexts in which science is considered problematic or authoritative (Fleury et al., 2019). Why does the IPCC face resistance and endless controversy in some countries (US) while securing public compliance, cooperation, and active support in others (such as Germany)?

For example, during the so-called "Climategate" controversy of 2009-10, thousands of emails between climate scientists were leaked, which some critics interpreted as showing scientific malpractice in efforts to exaggerate evidence for anthropogenic climate change. In the United

Kingdom, the debate focused on the trustworthiness of the individuals concerned; but in the USA, arguments raged about the supposedly hidden motivations of the scientists involved and about ways to ensure that science would no longer be polluted by politics (Jasanoff, 2011). Therefore, trust in expertise about climate change tends to reflect trust between citizens and the state. Moreover, factual controversies in policy contexts are often less about science's credibility than proxies for disagreements about competing ways of life or visions of the social contract between citizens and the state.

Other research has focused on the makeup of the IPCC itself, its internal rules for reporting findings "with one voice," or the influence of separating the "physical science" working group from other groups working on impacts and policies (de Pryck and Hulme, 2022). STS scholarship on climate change frequently calls for more diverse knowledges, problem framings, and normative frameworks to be given a seat "at the table."

In many ways, the IPCC embodies this need for epistemic plurality and engages three working groups spanning the physical sciences, the social sciences and even some humanities scholarship. However, observers from STS and related fields have long argued that there are problematic disciplinary, epistemological, gender and geographical skews in this formulation. For example, the social science components of IPCC reports, especially around mitigation, have been dominated by economics. Arguably, this skews the reports and subsequent public discussions towards certain possible "solutions" to climate change while side-lining others.

The IPCC has also historically been dominated by authors from or trained in the global North. More radically, we might recognize that expanding the geography of IPCC expertise also requires expanding the types of knowledge deemed relevant and credible. For example, as attention to regional climate change impacts grows, the work of scholars with deep knowledge of and connection with "local" environments, communities and cultures will become ever more relevant. There is also a widespread desire to integrate or elevate forms of "indigenous knowledge," such as from indigenous communities in Arctic regions into IPCC assessments. Yet, there are various challenges. Some might argue that indigenous and local knowledge cannot simply be added to the pantheon of peer-reviewed climate science because it comes from radically different ontological traditions, is usually oral rather than written, and is closely guarded. "Mining" such knowledge for usable insights into climate change might repeat the extractive colonialism experienced by such communities for centuries. A key task for STS

scholars is to help rethink and reconfigure practices of producing and assessing knowledge on climate change and rethinking the social compact of experts in society (Rashidi and Lyonsm, 2021). In turn, this might also mean analysing the discursive and dramaturgical factors underlying public performances of authority. How does knowledge enact politics (Hajer and Pelzer, 2018)? How can STS scholars, as authoritative knowers themselves, engage in these debates in responsive and reflexive ways?

STS has proven very adept at unpicking the knowledge practices of the powerful. The challenge is to incorporate these insights into environmental assessments, public debate, and policy interventions to show how to use these insights to make science and policy more inclusive and relevant for diverse needs.

Key Readings

Beck S and Mahony M (2018) The IPCC and the new map of science and politics. *Wiley Interdisciplinary Reviews: Climate Change* 9(6): e547.

de Pryck K and Hulme M (eds) (2022) *A Critical Assessment of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press.

Hulme M (2010) Problems with making and governing global kinds of knowledge. *Global Environmental Change* 20(4): 558–564.

Jasanoff S (2011) Cosmopolitan Knowledge: Climate science and global civic epistemology. In: Dryzek J, Norgaard RB and Schlosberg D (eds) *Oxford Handbook of Climate Change and Society*. Oxford: Oxford University Press, pp.129–143.

Jasanoff, S., and M. L. Martello (Eds). 2004. Earthly politics: local and global in environmental governance. Cambridge, Mass.: MIT Press.

Jasanoff, S., and B. Wynne. 1998. Science and decisionmaking. In *Human Choice and Climate Change*, eds. S. Rayner and E. Malone, 1-87. Columbus, OH: Battelle Press.

Latour B (2018) *Down to Earth: Politics in the New Climatic Regime*. London: Polity.

Lövbrand E, Beck S, Chilvers J et al. (2015) Who Speaks for the Future of Earth? How Critical Social Science Can Extend the Conversation on the Anthropocene. *Global Environmental Change* 32: 211–18.

Miller, C. A., and P. N. Edwards. 2001 (Eds). *Changing the atmosphere: expert knowledge and environmental governance*. Cambridge, Mass. ; London: MIT Press.

Other References

Agarwal A and Narain S (1991) *Global warming in an unequal world*. Delhi: Centre for Science and Environment.

Baker Z (2017) Climate state: Science-state struggles and the formation of climate science in the US from the 1930s to 1960s. *Social Studies of Science* 47(6): 861-887.

Blok A (2010) Topologies of climate change: actor-network theory, relational-scalar analytics, and carbon-market overflows. *Environment and Planning D: Society and Space 28*(5): 896-912.

Burton I (2009) Climate change and the adaptation deficit. In: Schipper EL and Burton I (eds) *The Earthscan Reader on Adaptation to Climate Change.* London: Earthscan, pp.89-98.

Carton W, Asiyanbi A, Beck S et al. (2020) Negative emissions and the long history of carbon removal. *Wiley Interdisciplinary Reviews: Climate Change* 11(6): e671.

Chakraborty R and Sherpa PY (2021) From climate adaptation to climate justice: Critical reflections on the IPCC and Himalayan climate knowledges. *Climatic Change* 167(3):49.

Chilvers J, Bellamy R, Pallett H and Hargreaves T (2021) A systemic approach to mapping participation with low-carbon energy transitions. *Nature Energy* 6(3): 250-259.

Edwards PN (2010) *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming*. Cambridge, Mass.: MIT Press.

Fleury LC, Miguel JCH and Taddei R (2019) Climate change, science and society. *Sociologias* 21: 18–42.

Forsyth T and McDermott CL (2022) When climate justice goes wrong: Maladaptation and deep co-production in transformative environmental science and policy. *Political Geography* 98:102691.

Hajer MA and Pelzer P (2018) 2050—An energetic odyssey: Understanding "technologies of futuring" in the transition towards renewable energy. *Energy Research & Social Science* 44: 222-231.

Miller CA and Wyborn C (2018) Co-production in global sustainability: Histories and theories. *Environmental Science and Policy* 113: 88-95.

Rashidi P and Lyons K (2021) Democratizing global climate governance? The case of indigenous representation in the Intergovernmental Panel on Climate Change (IPCC). *Globalizations* 1-16.

van der Sluijs J, van Eijndhoven J, Shackley S et al. (1998) Anchoring Devices in Science for Policy: The Case of Consensus around Climate Sensitivity. *Social Studies of Science* 28(2): 291-323.

Commented [TF1]: This is the references as it appears on the journal website. It seems it does not have a journal issue ! It has already been cited by other papers in the form we use here.