

Visualizing Carbon Inequity and Climate Responsibility¹

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Climate change, like the carbon dioxide (CO₂) that contributes to anthropogenic warming as a greenhouse gas, is invisible, as are many of its risks, impacts, and victims.² Our inability to perceive either directly through our senses (visual or otherwise) presents a number of challenges, not least of which relates to the communication of its urgency and salience to those responsible for it and thus in a position to mitigate that responsibility. This invisibility makes neither of these invisible things any less pernicious, for as Rachel Carson suggests of radiation and synthetic chemicals they together cast “a shadow that is no less ominous because it is formless and obscure.”³ But this invisible gas and abstract phenomenon can be *visualized*, or rendered visible through narrative or imagery that constructs and conveys its meaning, with such visualization constituting a representational intervention that can potentially communicate the urgency and salience of ongoing human disruptions of the carbon cycle. Effective visualization of carbon and climate can generate attention and mobilize action in ways that are suggested by a diverse array of scholars, relying on techniques and concepts from a variety of disciplinary perspectives. In this paper, I consider characteristics of effective visualizations of carbon and climate in terms of how these shape the social imaginary and open pathways to more just and sustainable futures.

The representation of climate change through visual images can be understood and evaluated discursively; that is, in terms of its narrative about normative and empirical aspects of human relationships with carbon and climate. It can direct our attention toward some causal factors or responsible agents and away from others, opening or closing remedial options in the process, as well as highlighting or obscuring normative criteria (like equity) that may or may not inform those options. Fair and effective climate governance now depends upon an expansive and nuanced social imaginary that is capable of understanding the complex causality and the distant and obscure impacts of anthropogenic climate change and animating and incorporating possible

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² Luke Parry, Claudia Radel, Susana B. Adamo, Nigel Clark, Miriam Counterman, Nadia Flores-Yeffal, Diego Pons, Paty Romero-Lankao, Jason Vargo (2019), “The (in)visible health risks of climate change,” *Social Science & Medicine* 241, 112448.

³ Rachel Carson (1962), “Silent Spring III,” *The New Yorker*, 30 June issue, online at <https://www.newyorker.com/magazine/1962/06/30/silent-spring-part-3>.

responses that are normative defensible and practically efficacious. This expansive imaginary depends in turn upon effective visual presentation of the human relationship with carbon, where effectiveness is understood in terms of information that offer an accurate and coherent account of the causes and predicted impacts of climate change, identifies responsible actions and parties, and offers actionable and empowering identification of mitigation options, and where fairness is defined in terms of equity and principles that can also be visualized in such presentations.

In this paper, I analyze a variety of visualizations of the human relationship with carbon and climate, including some from climate science that seek to represent anthropogenic agency and to communicate urgency in mitigating climate change as well as other images from advocacy groups that seek to call attention to equity and differentiated responsibility dimensions of climate change. The paper also surveys an existing interdisciplinary literature on visualization in order to ascertain criteria for effective visualization and to understand its role in social mobilization and change and considers critical perspectives on power and visibility for their applicability to this kind of project. As a preface to a more comprehensive examination of visualization of carbon and climate, the paper aims to provide some basis in empirical and normative theories for the visualization of equity and responsibility in climate change.

Rendering the invisible visible

As Mike Hulme notes of this invisibility, climate (as opposed to weather) “cannot be experienced directly through our senses,” relying as it does on patterns and probabilities rather than anything that can be seen or felt.⁴ Climate itself is an abstraction of weather that requires decades of monitoring data in order to construct. It can only be attributed to any place upon accumulation of monitoring data sufficient to control for natural variation and anomalies—for the US National Oceanic and Atmospheric Administration (NOAA), this requires 30 years of data.⁵ As is often said to distinguish the two, “climate is what you expect and weather is what you get.” Of the abstraction involved in observing climate (through monitoring stations and instruments, which have the attention spans that human cognition does not), Hulme notes that “the farther back in time we look” at results of meteorological processes that we experience as

⁴ Mike Hulme (2009), *Why We Disagree about Climate Change* (New York: Cambridge University Press), p. 3.

⁵ <https://www.noaa.gov/education/resource-collections/climate/climate-data-monitoring>

rain or wind events in real time, “the more our reconstructions of the past rely upon notions of climate rather than weather.”⁶

Climate *change* requires even longer time scales to apprehend, since dynamism within an abstract temporal phenomena like climate requires still more temporality to manifest. It occurs over geologic rather than human time, which explains why paleoclimatology must rely upon indirect measurements of the planet’s historical climate from tree rings or ice sheets to charts changes to that climate. Weather events (or their impacts) that we attribute to climate change may be visible but both their source and atmospheric drivers defy direct sensory experience. We cannot experience climate, much less climate change, so the reality of either (and certainly also the meaning and motivational force of experiencing either in this way) requires visualization of phenomena that would otherwise have no reality for us, given constraints of human perception.

This invisibility—whether of CO₂, of climate, or of climate change—is viewed by environmental scholars as contributing to the lack of attention to or urgency for the problems with which these unseen things are associated. What is out of sight, as is often said, remains out of mind. But these three things can be *visualized*—that is, rendered visible through images and other forms of representation—and the visualization of carbon and its interaction with climate to produce climate change is intended to enable this attention and generate this urgency. Human interaction with carbon and the carbon cycle, with its impact on climate manifesting as climate change, can be visually represented through images that convey information but also generate affect and meaning. Effective visualization has been an objective of a range of disciplines, not least of which is the cluster of physical science specialties often referred to as *climate science*.

Climate science seeks to render the invisible phenomenon of climate change visible, whether through the Keeling Curve of increasing atmospheric concentrations of carbon dioxide (figure 1) or the “hockey stick” of increasing global mean temperatures (figure 2).⁷ Both of these visualizations intend to communicate facts about the human relationship with carbon and the carbon cycle, where human activities are now changing the planet’s climate, but both are also normative in their general implications for action. Anthropogenic climate change is presented not as a neutral fact that should be received within indifference but as a warning that should motivate

⁶ Hulme (2009), p. 9.

⁷ David Appell (2005), “Behind the Hockey Stick,” *Scientific American*, March 1. Online at <https://www.scientificamerican.com/article/behind-the-hockey-stick/>

at least a precautionary stance about the trends that the visualizations identify. This normative dimension is widely recognized by the scientists responsible for these efforts to render the invisible phenomenon visible, the public that views it, and critics that would prefer that the phenomenon remains invisible. According to Michael Mann, who developed the hockey stick graph and would later be required to defend it against such critics, those attacking his graph well understood its normative force. As he would later write about those critics, “perhaps they were afraid that general acceptance of the facts behind global warming and the risks it poses would lead the public to demand action to protect the future.”⁸

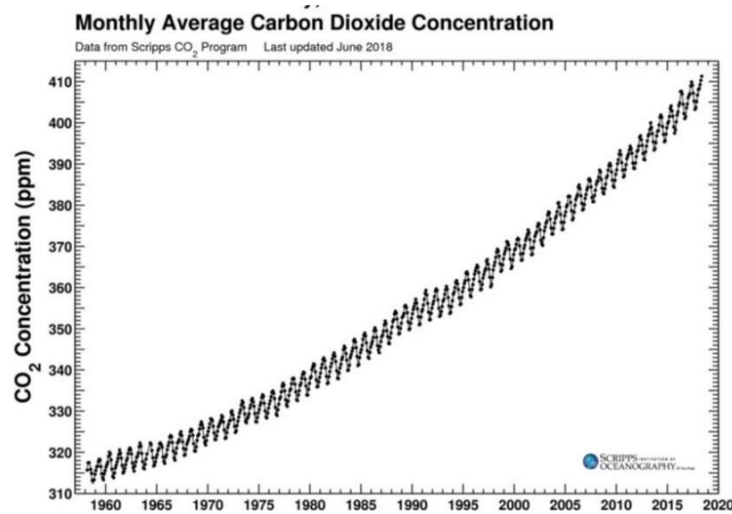


Figure 1: the Keeling Curve graph

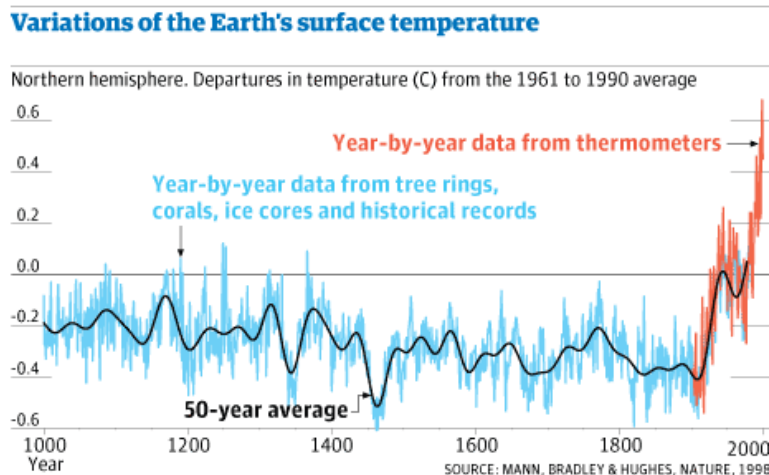


Figure 2: the “hockey stick” graph

⁸ Michael F. Mann (2012). *The Hockey Stick and the Climate Wars: Dispatches from the Front Lines* (New York: Columbia University Press), p. 22.

The visualization of climate change by climate scientists like Keeling and Mann is also to attribute *agency*—as an *anthropogenic* phenomenon, climate science seeks to link categories of human activities (fossil fuel combustion, deforestation, etc.) to this invisible abstraction such that human agency is an inextricable part of its narrative. Indeed, this agency has been so pervasive an aspect of the phenomenon (particularly during the “great acceleration” of this anthropogenic agency that has been underway since the mid-20th Century⁹) that many scientists now see it as marking a break in geologic time. Paul Crutzen, who coined the term recognizing the scope and scale of this agency, suggests that it is now “more than appropriate to emphasize the central role of mankind in geology and ecology by using the term ‘Anthropocene’ for the current geological epoch.”¹⁰ Climate change may only occur over geologic time, since it requires such time scales in order to observe, but now it also marks a break in such time, ushering in a new epoch defined by the power and reach of human agency over planetary processes, if not in humanity’s ability to direct or control it. Visualizing anthropogenic climate change through climate science has been fundamentally concerned with observing, documenting, and attributing human agency.

While creating a powerful picture of human agency over the planet’s ecology, the project of visualizing climate change (along with carbon and climate) through climate science has been less successful at redirecting that agency away from the catastrophic outcomes that it predicts. To be sure, awareness of and concern about anthropogenic climate change has increased, partly as the result of such visualization, resulting in changes from “business as usual” emissions trajectories (another abstraction that has been given form through visualization), and such mitigation efforts are tremendously important in beginning a sustainable transition away from fossil fuels, but taken together they remain insufficient for meeting even the modest climate goal of avoiding more than 2 degrees of warming set through the 2015 Paris Agreement. Insofar as the *raison d’etre* for visualizing climate change through climate science has been to motivate and/or exert control over human activities that contribute toward its problems, which is assumed

⁹ Steffen, Will; Broadgate, Wendy; Deutsch, Lisa; Gaffney, Owen; Ludwig, Cornelia (2015). "The trajectory of the Anthropocene: The Great Acceleration". *The Anthropocene Review* 2(1): 81–98.

¹⁰ Eckart Ehlers, Thomas Krafft (eds.). *Earth Systems Science in the Anthropocene: Emerging Issues and Problems*. (2006)

to result from humanity's becoming *aware* of its agency in this context, the presumed link from recognition to redirection of such agency has not yet occurred on a sufficient scale.

Some critics cite this failure as evidence that visualization of abstractions like climate change (or perhaps even the abstraction itself) is counterproductive to this end of sustainable transition; that as a "regime of visibility" the visualization of climate change through climate science involves a pernicious form of Enlightenment hubris or invokes green governmentality, mobilizing a power of states that is ill-equipped for the task to which it has been put. Others are more sanguine about the potential of efforts to visualize climate change but criticize climate science for its claims to epistemic authority over the construction of the phenomenon, with some arguing for more inclusive and democratic forms of climate knowledge coproduction and others seeking to broaden the disciplinary fields utilized in such visualization to include the arts and humanities alongside (or sometimes as an alternative to) incumbent visualization hegemony in paleoclimatology and meteorology. Here, the task of visualization is recognized as explicitly and unapologetically normative and the goal as one of not only providing *insight* into the causes and consequences of climate change but also in cultivating *foresight* into humanity's relationships with carbon and climate, and (from these) in empowering and motivating change (whether to actions, ontologies, norms, structures, or consciousness).

Visibility and its discontents

Has carbon or climate visualization failed to generate the sort of attention or urgency that its advocates seek, or is it doomed to fail, as suggested by some critics? Or may we instead distinguish between more and less effective visualizations, whether of our relationships with carbon, of climate and climate change? Before proceeding with the question of effectiveness we must attend to the question of whether visualization is doomed to fail, which would preclude the former. In this section, I explore critical perspectives on carbon and climate visualization with the aim of assessing what is sometimes taken to be an objection against the rendering of invisible things as visible, assumed to be accompanied by an objectionable form of power based in visibility.

To back up a step, one may ask whether (*contra* my assertions above) climate change *is* visible in the sense of being observable through the senses, since as Peter Rudiak-Gould notes

“there would be no need to visualize it [climate change] if it could already be seen.”¹¹ Here, we may distinguish between what Rudiak-Gould terms *visibilism* and *invisibilism*, which he casts as ideological positions on whether such abstract phenomena defy direct sensory detection that are bound up in rival ontologies and epistemologies as well as implicit normative commitments. As he notes, physical scientists and experimental psychologists tend to be drawn to climate change *invisibilism* from an Enlightenment epistemology through which modern science allows for the transcendence of human fallibility, which is on display in “the temptation to regard the weather (read: local, subjective experience), while human redemption is the effort to measure the climate (read: global, objective fact).” Invisibilism is appealing to this group, Rudiak-Gould suggests, because it stems from “a particular political outlook in which scientific authority is central,” and flatters those whose expertise lies in studying invisible phenomena like climate change, given that “the scientific claim to authority hinges on its ability to perceive what cannot be seen.”¹²

This epistemic authority to “perceive what cannot be seen” thus becomes a claim to other forms of authority. Lay persons that are unable to perceive these invisible phenomena are, like the prisoners in Plato’s cave allegory, to be directed toward the truth by their epistemic superiors, since they are unable to perceive or apprehend that truth directly. Such invisibilism (with its accompanying epistemic elitism) is on display in the American Psychological Association Task Force on the Interface Between Psychology and Global Climate Change’s 2009 report, which as Rudiak-Gould notes makes this connection between expertise and authority explicit:

Because climate change is so hard to detect from personal experience, it makes sense to leave this task to climate scientists. This makes climate change a phenomenon where people have to rely on scientific models and expert judgment and/or on reports in the mass media, and where their own personal experience does not provide a trustworthy way to confirm the reports.¹³

Insofar as the visualization of climate change proceeds from such technocratic presumptions, charges of antidemocratic elitism seem fair. Its embrace of scientism and marginalization of

¹¹ Peter Rudiak-Gould (2013), “‘We Have Seen It with Our Own Eyes’: Why We Disagree about Climate Change Visibility,” *Weather, Climate, and Society* 5(2): 120-32, 121.

¹² Rudiak-Gould (2013), 123.

¹³ Swim, J., S. Clayton, T. Doherty, R. Gifford, G. Howard, J. Reser, P. Stern, and E. U. Weber, 2009: *Psychology and Global Climate Change: Addressing a Multifaceted Phenomenon and Set of Challenges*. Report of APA Task Force on the Interface between Psychology and Global Climate Change, 108 pp. [available online at www.apa.org/science/about/publications/climate-change-booklet.pdf.], 22.

other epistemologies also invite charges of reproducing colonial hierarchies while also clinging to an untenable account of scientific objectivity. But visibilism can also be problematic, since it often embraces anti-intellectualism that can foster forms of science denialism, rejecting findings of the physical sciences along with its claims to authority. It also simultaneously “encourages in frontline communities a disempowering self-perception of hopeless, inherent vulnerability” as they serve as the world’s “climate canaries,” Rudiak-Gould suggests, while feeding “Western audiences the comforting fantasy that climate change, and climatic vulnerability, are safely distant from their own communities.”¹⁴

Considered in terms of their ideological commitments, neither visibilism nor invisibilism appear to be immune to serious objections. Fortunately, Rudiak-Gould identifies an alternative to either in what he terms “constructive visibilism,” which denies that climate change is inherently visible or invisible—that “it is, like all other objects, *made* visible” through symbols or events that are vested with narrative connections to the otherwise-abstract phenomenon. For example, the Climate Witness Project “adds new voices to the climate narrative as witnesses describe the changes they are seeing right before their eyes,” casting the testimonies of “scientists, farmers, fishermen, and everyday citizens” as experiencing climate change itself.¹⁵ Those “witnessing” climate change on the ground can potentially contribute valuable knowledge and experience to our collective understanding of the phenomenon, even if Rudiak-Gould’s use of the example to challenge the dichotomy relies upon a semantic slippage between climate change and its impacts. Even the most dogmatic invisibilist would allow that climate impacts can be experienced, even if a definitive link to anthropogenic drivers remains elusive.

Rudiak-Gould casts constructive visibilism as a more capacious ontology that is capable of transcending the narrow ideological commitments that divide visibilists and invisibilists. Its synthesis would be attractive, even if practical examples are thus far elusive. As he aspirationally suggests, transcending the dichotomy could mean that “sensory experience on the ground breathes life and urgency into desiccated expert assessments, while scientific generality serves to unite disparate communities around the travelable concept of climate change and methodological

¹⁴ Rudiak-Gould (2013), 129.

¹⁵ <https://www.climatewitnessproject.org/>

skepticism provides a cautionary counterpoint to overexuberant local attribution.”¹⁶ However it might arise, this more capacious ontology recognizes the value of multiple epistemologies in understanding climate change (which, as an abstract phenomenon includes both its causes and effects) rather than claiming epistemic authority for any particular way of knowing. It recognizes the importance of representation, where both the hockey stick graph and testimonials from frontline observers count as valid representations of a phenomenon that may be an invisible abstraction but also has visible manifestations. Most of all, it is pragmatic about the value and purpose of representing climate change, which is more about providing insight and foresight than creating pure knowledge or objective truth.

Another set of critical perspectives on visibility and visualization can be found in work on what is sometimes referred to as regimes of visibility and abstraction, which casts visibility and visualization as a tool of disciplinary power. As James Scott observes of modern states, and capturing a cornerstone of this critical perspective, *legibility* is often imposed upon nature or people through the bringing “into sharp focus certain limited aspects of an otherwise far more complex and unwieldy reality,” which is intended to make “possible a high degree of schematic knowledge, control, and manipulation.”¹⁷ Since legibility seeks to make things visible in order to more efficiently control them, and given Scott’s reliance on visual terms to capture this form of power, one might assume that the visualization of carbon or climate involves a form of legibility.

As Scott writes, state power “requires the invention of units that are visible,” where it is the visibility and legibility of subjects that allows for effective state control. “Whatever the units being manipulated,” Scott writes, “they must be organized in a manner that permits them to be identified, observed, recorded, counted, aggregated, and monitored.” For Scott, this imposition of legibility involves “the combination of the universalist pretensions of epistemic knowledge and authoritarian social engineering” and typically cause “irreparable damage to human communities and individual livelihoods,” usually as an unintended consequence of ostensibly progressive social reform. Indeed, Scott condemns the “high-modernist” optic that casts its statist gaze with “resolute singularity” at activities for the purpose of simplification, as scientific forestry viewed forests only as a source of commercial wood products, with disastrous results. Viewing human

¹⁶ Rudiak-Gould (2013), 129.

¹⁷ James C. Scott (1998), *Seeing Like a State: How Certain Schemes to improve the Human Condition Have Failed* (New Haven, CT: Yale University Press).

activities in terms of their carbon footprints involves a similar simplification, and a comparable imposition of legibility, such that Scott's critique should give pause regarding visualization.

Other critics likewise condemn exercises of state power through regimes of visibility that resemble those of carbon or climate visualization efforts that employ a kind of surveillance in the service of disciplinary normalization (as rendering carbon footprints visible seeks to identify polluting acts and in so doing deter them, normalizing actions or lifestyles cast as "sustainable" and casting more polluting ones as deviant). Disciplinary power, like Bentham's panopticon and Scott's legibility, works by rendering the invisible or obscure fully visible, and thus subject to the normalizing gaze. As Foucault writes in *Discipline and Punish*, "visibility is a trap" as it "assures the automatic functioning of power." Later, he would cast such power in terms of an imperative (termed *governmentality*) to control the conduct of persons or groups; although cast by Foucault in largely descriptive terms this form of power is usually received pejoratively. In the context of state efforts at environmental protection, eco-governmentality claims authority on the part of the "eco-knowledgeable" to "police the fitness of all biological organisms and the health of their natural environments,"¹⁸ which could apply to decarbonization efforts that rely on visualized carbon or the visualization of climate change. Scholars of governmentality in other areas of environmental politics likewise view linkages between power and visibility in a similar pejorative fashion, seeking to link pathologies of state control with Foucauldian conformism or the kinds of disastrous consequences that Scott identifies.¹⁹ Attention to such potential downside potential might therefore be necessary component of any defense of visualization.

One final critical perspective on such regimes of visibility might be registered. Julia Doyle notes that visual images often accompany environmental campaigns by states as well as ENGOs like Greenpeace, aestheticizing the natural world in the process of valuing it, which as she argues "further externalizes the environment, offering it up as a form of visual consumption, either through 'capturing' this beauty in the form of pictorial representation, or through the practice of tourism as the 'tourist gaze'."²⁰ While visual images offer powerful representations of

¹⁸ Luke, Timothy W. (1999) "Environmentality as Green Governmentality." in Darier, E. ed. *Discourses of the Environment*. Malden, Mass: Blackwell Publishers. 121-151, p. 146.

¹⁹ Trevor L. Birkenholtz (2015), "Recentralizing groundwater governmentality: rendering groundwater and its users visible and governable," *WIREs Water* 2(1): 21-30.

²⁰ Julia Doyle (2011), *Mediating Climate Change* (Farnham, UK: Ashgate), p. 22.

phenomena like climate change, they also privilege the visual (as a means of understanding but also in terms of what can and what cannot readily be visualized), which can be add odds with the temporal pace of the phenomena they aim to represent. As Doyle notes, reliance on photographs to represent a slowly-unfolding and visually elusive phenomenon like climate change can result in a “temporal disjuncture” between “scientific praxis which authenticates knowledge through reference to the visible present, and the effects of climate change which develop and accumulate, often invisibly and neither temporally or spatially consistent, over time.”²¹

Such critical perspectives cannot be dismissed but they can be engaged and their force be incorporated into how visibility or visualization is used as a form of representation. To the worry about the gaze of power and the disciplinary power that emanates from it, including concerns about abuses of power or unintended by disastrous consequences, it is worth distinguishing two different uses of visuality in the context of carbon and climate. Carbon disclosure or footprinting offers a visual tool to diagnose practices that generate the polluting gases that cause climate change. Foucauldian governmentality concerns about disciplinary power and the normalization of sustainable behaviors are valid, but must be weighed against the potential for such visual tools for averting worse outcomes through the kind of power that they mobilize. But that is for another paper, since the visual here is being used not to surveil ongoing practices or behaviors but rather to represent how past practices might be connected to various futures, and in so doing inform and enable the viewer to better construct and more effectively advance more attractive futures. Visual representation is intended to enhance the agency of an empowered public, with power emanating from the visual representation and to its viewer, rather than its opposite, where in the panopticon power flows from seen subject to viewing authority, diminishing the agency of the public.

Why and how to visualize carbon and climate

Not only is climate change itself somethings that only unfolds slowly, over geologic time, but many of its impacts also defy sensory observation. They involve what Rob Nixon calls “slow violence” and describes (in visual terms) as “a violence that occurs gradually and out of sight, a violence of delayed destruction that is dispersed across time and space, an attritional violence

²¹ Doyle (2011), p. 25.

that is typically not viewed as violence at all.”²² For Nixon, the invisibility of such violence, which he associates quintessentially with climate change, entails a representational challenge: “how to devise arresting stories, images, and symbols adequate to the pervasive but elusive violence of delayed effects.”²³ In both its causes and effects, climate change challenges conventional visual forms of representation because its impacts are “low in instant spectacle but high in long-term effects” but occurs in a world with a short attention span and which is reliant on “sensation-driven technologies of our image-world” for feedback. In his book, Nixon seeks effective representations of such violence in written narrative rather than visual imagery, but his call for intervention is nonetheless appropriate for visualization efforts that involve “devising iconic symbols that embody amorphous calamities as well as narrative forms that infuse those symbols with dramatic urgency,”²⁴ which visual images of carbon and climate also do.

As Nixon suggests, visualization of phenomena like climate change is necessary for such invisible forms of violence to be represented to a public that cannot otherwise perceive its causes or effects, with such representation giving it a palpable social reality. Another way of expressing the same idea is to identify visualization’s purpose as the construction of a new social *imaginary*, since representation is aimed at the collective imagination. Charles Taylor casts modernity itself as a kind of social imaginary, which he describes as including “the ways people imagine their social existence, how they fit together with others, how things go on between them and their fellows, the expectations that are normally met, and the deeper normative notions and images that underlie these expectations.”²⁵ This merging of causal accounts of reality with normative terms of evaluation constitutes an imaginary and allows its interpretive and prescriptive power.

While Taylor’s focus in tracing the development of a distinctively modern and Western social imaginary is on the past, the shared vision of social imaginaries can also have a future orientation, where past experiences are connected to alternative possible futures and animated by either hope or fear associated with those futures. Manjana Milkoreit, for example, defines “socio-climatic imaginaries” as “collectively held visions of the future, both desirable and undesirable,

²² Rob Nixon (2011), *Slow Violence and the Environmentalism of the Poor* (Cambridge, MA: Harvard University Press), p. 2.

²³ Nixon (2011), p. 3.

²⁴ Nixon (2011), p. 10.

²⁵ Charles Taylor (2003), *Modern Social Imaginaries* (Duke University Press), p. 23.

that are informed by science and can support deliberation and decision-making in the present.”²⁶ Here, imaginaries result from meaning-making activities can motivate changes to behaviors, institutions and structures through their ideational power, and depend on “mental representations of what is not *yet* present.” For purposes of this project, Milkoreit’s socio-climatic imaginaries utilize “transformational narratives” to imagination to capture “dimensions of the world that are real but simply not open to sensual experience” (which is also the core objective of visualizing carbon and climate), including “abstract ideas like democracy” as well as abstract phenomena like climate change. They link past to possible futures, capture “causality beliefs” that associate actions with outcomes and define both the possible and the desirable.

In considering the effectiveness of visualization of climate change, the two main criteria identified within the literature are salience and engagement. Images that convey to viewers the sense that climate change is important make it salient for viewers, which increases the sense of priority or weight relative to other concerns, while engagement conveys a sense of efficacy or empowerment in viewers. If an image conveys a high sense of salience but a low measure of engagement, viewers experience anxiety about the problem but do not believe that they can make a difference through their action while low salience and high engagement may empower viewers to act but conveys little reason for them to prioritize such action or accept costs associated with it. Ideally, then, images would convey both high salience and high engagement.

O’Neill and Nicholson-Cole examine the efficacy of various visual representations of climate change along these two dimensions, using focus groups and semi-structured interviews to capture reactions to visual images but also how participants viewed the future. Consistent with other research that finds apocalyptic framing of climate change to be disempowering,²⁷ the authors find images that induced fear in the context of climate change to convey a sense that climate change was important but “were found to enhance a sense of fatalism and thus act to encourage disengagement with climate change rather than positive engagement.”²⁸ The most effective images were “those clearly showing what people can do personally,” which conveyed a

²⁶ Manjana Milkoreit (2017), “Imaginary politics: Climate change and making the future,” *Elementa: Science of the Anthropocene* 5(62).

²⁷ Crist E (2007) Beyond the climate crisis: a critique of climate change discourse. *Telos* 141:29–55.

²⁸ Saffron O’Neill and Sophie Nicholson-Cole (2009), “‘Fear Won’t Do It’ Promoting Positive Engagement With Climate Change Through Visual and Iconic Representations,” *Science Communication* 30(3): 355-79, 370.

sense of personal efficacy, with “local impact images” that “communicate a local relevance” while also including a global context “to make the seriousness of the issue resonant.”²⁹ In a later study with Boykoff, Niemeyer and Day, O’Neill again found images that focused on impacts to generate a fear and anxiety response, which promotes salience but undermines self-efficacy, while “images picturing different energy futures appeared to strongly enhance feelings of self-efficacy.”³⁰ The authors suggest of this latter sort of imagery that self-efficacy in the context of climate and energy futures enabled a sense of “carbon capability,” which is elsewhere defined as related to “the contextual meanings associated with carbon” and referring to “an individual’s ability and motivation to reduce emissions within the broader institutional and social context.”³¹

Similar observations about effective visualization are found in Stephen Sheppard’s work, which calls on science communicators and practitioners to follow insights from climate visual research. These insights include the importance of connecting local causes to remote impacts, drivers of climate change to mitigation and adaptations solutions, and current trends to possible futures, as noted above. Sheppard also stresses the importance of developing an ontology of carbon (which he calls “carbon consciousness”) through its visualization, noting the value of conveying “where carbon comes from and how we use it dictates how it accumulates in the atmosphere and oceans, and how the effects eventually appear on our own doorstep.”³² While emphasizing the importance of “honest and accurate visualizations with high standards of defensibility,” Sheppard defends visualization not primarily as a means of providing information about the causes and effects of climate change, but as generating insight and foresight about it, to “enable us consciously and collectively to decide if this is how we wish to continue.” As he notes of such visualization, “some truths are too important to remain invisible.”³³

Key to cognitive and affective impacts of carbon and climate visualization is the role of emotion on agency. Visual images can communicate information, but their far more powerful

²⁹ O’Neill and Nicholson-Cole (2009), p. 374.

³⁰ SJ O’Neill, M Boykoff, S Niemeyer, and S Day (2013), “On the use of imagery for climate change engagement,” *Global Environmental Change* 23:413–421, 419.

³¹ Lorraine Whitmarsh, Saffron O’Neill, Gill Seyfang, and Irene Lorenzoni (2009), “Carbon Capability,” in *The Handbook of Sustainability Literacy*, ed. by Arran Stibbe (Totnes, UK: Green Books), 124–29.

³² Stephen R.J. Sheppard (2012). *Visualizing Climate Change: A Guide to Visual Communication of Climate Change and Developing Local Solutions* (London: Routledge), 63.

³³ Sheppard (2012), p. 133.

impacts comes from their ability to convey narrative and meaning, which appeals to a different kind of mental processing than does purely rational or informational communication. As Joffe notes, in contrast with textual or verbal communication visual images “send people along emotive pathways where textual/verbal material leaves them in a more rational, logical and linear pathway of thought.”³⁴ In this sense, “the visual provides a counterpoint to the statistic,” since it speaks to affect and emotion, without which “information lacks meaning” and “will not be used for judgement and decision-making.”³⁵ Visual images thus uniquely provide a context for facts and information as well as infusing those with values and meaning such that viewers can not only be informed about problems like climate change on an intellectual level but also be moved to act on that information on an affective or emotive level.

Emotion plays a similar role in climate denial, which can prevent mobilization of social actions in response to climate change. In her book-length study of the role of emotions in denial, Kari Norgaard notes the dominance of the “information deficit” model, which holds that “the public fails to respond because of a lack of information” in favor of a “social organization of denial” model, in which “the public on a collective level actively resists available information.”³⁶ Here, public thought communities around climate change are socially constructed and normative, with denial becoming a condition of “knowing and not knowing,” as members of communities collectively agree about which observable facts to recognize and which to suppress, which in the context of climate denial “becomes natural, like everyday life, and thus invisible.”³⁷ The sense (or lack thereof) of personal and collective efficacy discussed above contributes to this effect, since emotive responses require a coherence that registers as cognitive dissonance in its absence. On a personal level, “unless they feel able to do something about the problem,” or have a sense of self-efficacy, “an awareness of concern or sense of responsibility would be a conflicting cognition.” Socially, denial becomes attractive as persons are “overwhelmed” by recognition of “the enormity of the problem” but lack any “clear sense of what can be done” and don’t know

³⁴ Hélène Joffe (2008), “The power of visual material: persuasion, emotion and identification,” *Diogenes* 55(1): 84–93, p. 84.

³⁵ Joffe (2008), p. 89.

³⁶ Kari Marie Norgaard, *Living in Denial: Climate Change, Emotions, and Everyday Life* (Cambridge, MA: The MIT Press, 2011), p. 12.

³⁷ Norgaard (2011), p. 60.

“whether the political system is up for the task, and whether their attempt to respond will generate even further problems.”³⁸

Norgaard’s study reinforces findings discussed above regarding effective visualizations and their relation to social imaginaries and collective action. Socially organized denial, she notes, results from “the absence of a well-developed sociological imagination that connects individuals to society and the local to the global,” which has “powerful implications for social action.”³⁹ “Without sensing a genuine reason to engage,” she suggests, “individuals withdraw from the political as a self-protective response.”⁴⁰ If the connection between local weather and global climate can be effectively visualized, she notes, “doing so magnifies their perceived seriousness and failing to do so makes them seem less significant, less real.”⁴¹ Conversely, given imagery that conveys more constructive engagement and efficacy, which can “reconnect the rifts in time and space that have constructed climate change as a distant issue,” allowing persons to imagine a more hopefully future and appreciate their connection to it, binding persons together in political communities that empower them “as a democratic collective to develop an authentic means of collectively participating in the direction of our future.”⁴²

Visualizing equity and responsibility

Visualizations from climate science like the Keeling Curve and hockey stick graph are able to capture an undifferentiated anthropogenic agency, through which humanity as a whole is responsible for disrupting the planet’s ecology by changing its climate, but crucial to the equity dimension of climate change is the differentiated responsibility by which persons and groups differ widely in their historical and ongoing contributions to the phenomenon. Capturing and visually conveying the highly inequitable carbon access or carbon footprints among persons and groups would not only help to connect local actions and global practices to climate change, which as noted above is key to establishing high levels of perceived efficacy, but might also be able to articulate the injustice of climate change, which underscores its salience or seriousness.

³⁸ Norgaard (2011), p. 193.

³⁹ Norgaard (2011), p. 100.

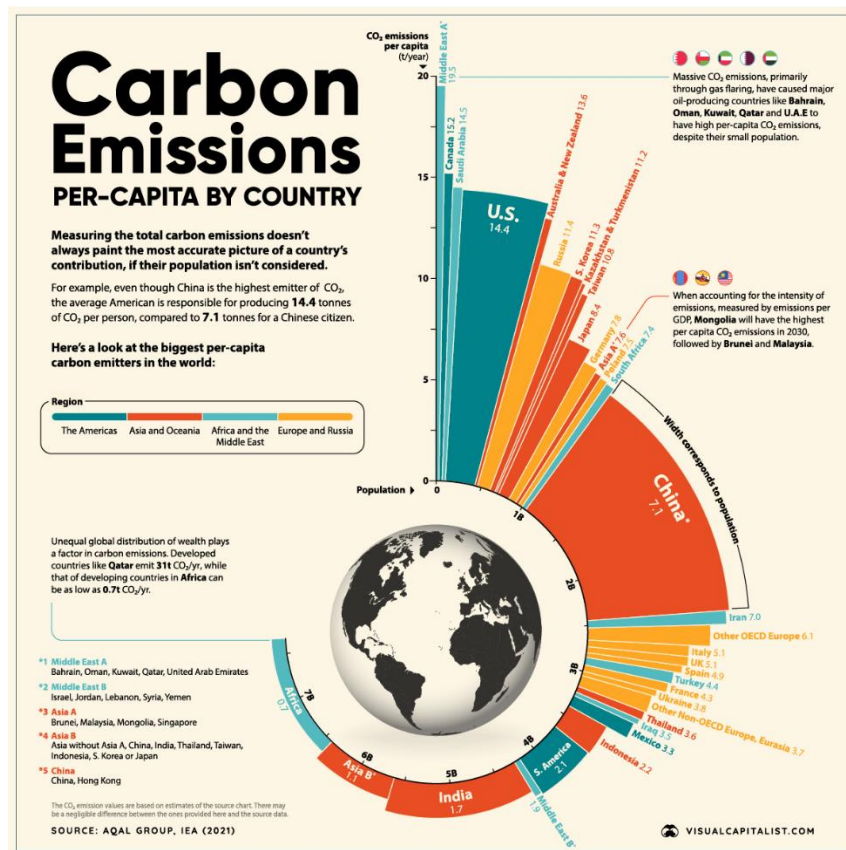
⁴⁰ Norgaard (2011), p. 226.

⁴¹ Norgaard (2011), p. 117.

⁴² Norgaard (2011), p. 222.

As Jerome Whittington notes, focusing on differentiated carbon access “increasingly serves to sort out the highly unequal but collective effects of human affairs on the atmosphere” (lending substance to the recognition of “common but differentiated responsibilities”), but also connects persons to larger structures, since “even people with very little direct responsibility for carbon emissions are dependent on an economy that requires continued fossil energy consumption.”⁴³

How can such differentiated responsibility for climate change be visually represented, and how might its effectiveness be assessed? Key to capturing the relevant facts is the ability to convey multiple comparative dimensions of such responsibility. Focusing on disparities in per capita emissions across nation-states offers a common metric for differentiated responsibility, which in combination with population size yields a visual image that conveys relative national contributions. The image below captures and conveys differentiated national and regional CO₂ emissions, visualizing variation in per capita emissions as well as national shares of the total.



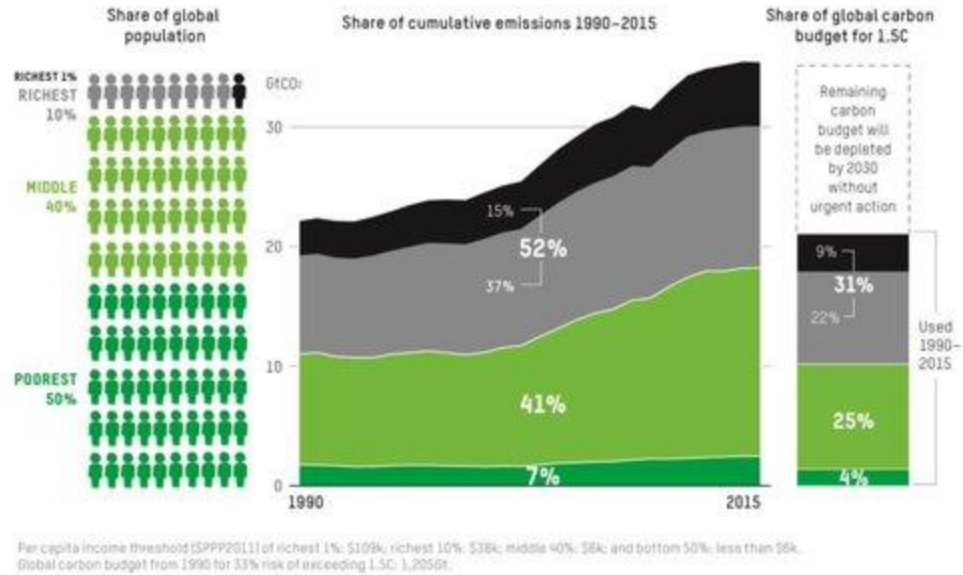
Source: <https://www.visualcapitalist.com/visualizing-global-per-capita-co2-emissions/>

⁴³ Jerome Whittington (2016), “Carbon as a Metric of the Human,” *PoLAR: Political and Legal Anthropology Review* 39(1): 46-63.

Along with its explanatory key, which links economic inequality to inequities in carbon access, this visual image captures two important ways in which CO₂ emissions might be differentiated among nation-states (which are parties to the UN Framework Convention on Climate Change and thus the parties to which the CBDR principle is directed): by per-capita emissions, which would make the US among the world's most responsible parties for purposes of assessing remedial liability, or by total emissions (controlling for population), which identifies China as the most responsible national party. While the image effectively captures these disparities, it lacks any narrative connection between this inequality in national contributions to climate change and its expected impacts, which are also likely to be highly differentiated, focuses on national emissions and so fails to capture links between economic and carbon inequality within such states, and lacks an explicitly normative claim about equitable carbon access.

The following visual image (from Oxfam) capture and convey several elements of carbon inequity that the above graphic ignores. By focusing on income rather national membership, the image more accurately represents links between economic and carbon inequality, visualizing the shares of cumulative emissions between 1990 and 2015 by income group (by the richest 1%, by the top 10%, by the middle 40%, and by the poorest 50%), showing also the total shares of each group over the period. By including a temporal dimension in the middle graphic, the image shows not only the overall growth in CO₂ emissions over the period but also growth within each income group. By capturing the increases in overall emissions over a period in which the global community had acknowledged the importance of climate change mitigation (with the UNFCCC having been adopted in 1992, the Kyoto protocol in 1997 and the Paris Agreement in 2015), both the failure of such mitigation efforts and the increasing urgency of decarbonization and visually captured and conveyed. Finally, the visual depiction of each income group's share of historical emissions within a carbon budget framework shows not only that current emissions trends will exhaust the remaining carbon budget for the 1.5° C temperature target set at Paris, but show also the relatively large shares of this budget used by the richest 10% and 1% (which together account for 40% of the post-1990 emissions that humanity can afford) alongside the relatively small (4%) share for which the poorest half of humanity is responsible. While the image does not explicitly identify an equitable emissions share for all persons, it clearly condemns existing disparities in carbon access as highly inequitable, thereby conveying a climate justice narrative through which climate change is cast as primarily about inequity in causation or differentiated responsibility.

Figure 1: Share of cumulative emissions from 1990 to 2015 and use of the global carbon budget for 1.5C linked to consumption by different global income groups



Source: Oxfam (2020), “Confronting Carbon Inequality”

By combining an equity-based normative analysis of differentiated responsibility for climate change within a visualization of carbon access over time combined with a finite carbon budget necessary for meeting established global temperature targets, the image represents some of the most important normative dimensions of climate change. While its presentation primarily conveys factual information, its narrative and meaning-making value improves upon those images that convey only undifferentiated anthropogenic human agency by identifying the core challenge of responding to climate change as one of equity. This climate justice framing ought to convey seriousness and salience, but as noted above must also convey a sense of personal or social efficacy and engagement if it is to effectively motivate remedial action. Whether the stark reality of wide inequality in carbon access overwhelms viewers with a sense of the enormity of the problem and difficulties in gaining leverage on such an intractable driver as global inequality or instead connects climate change with other experiences of injustice in a potentially generative way is a question for further research. Likewise with visualization of imperatives of connecting local causes to global impacts and conveying wide inequities in impacts and vulnerabilities, but these images evoke of the potential for capturing and conveying a richer narrative with greater critical purchase on harmful social practices about the causes and effects of climate change.