Attribution science and litigation: facilitating effective legal arguments and strategies to manage climate change damages

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1. Introduction

Growing number of lawsuits seek to use the courts to bring action on climate change. The objectives of these lawsuits include compelling governments and corporates to reduce greenhouse gas emissions, preventing the financing and construction of high-emitting infrastructure, and ensuring businesses and banks disclose their exposure to financial risks associated with climate change. A subset of these cases makes claims relating to climate change impacts. In most of these cases, plaintiffs (1) seek compensatory damages for losses incurred as a result of defendants' greenhouse gas emissions ('damage liability cases'), or (2) ask courts to compel defendants, primarily governments or corporations, to reduce emissions. These cases therefore hinge on courts finding that a causal relationship exists between the defendants' emissions and the plaintiffs' losses (typically to determine standing in the latter category).

The last decade has seen a rapid growth in climate litigation in an increasing range of jurisdictions, including significant developments in successful pro-regulatory litigation in Global South jurisdictions.[1] Parallel to this growth in litigation, recent scientific advances (termed 'attribution science') now allow causal relationships to be established between greenhouse gas emissions and climate-related events. It is logical, therefore, that attribution science should serve as the key source of evidence upon which causal claims are made in relevant climate lawsuits. Previous legal scholarship has outlined the potential role of attribution science in

[1] Jacqueline Peel and Jolene Lin, 'Transnational Climate Litigation: The Contribution of the Global South', *American Journal of International Law*, 113.4 (2019), 679–726 <https://doi.org/10.1017/ajil.2019.48>. Successful pro-regulatory cases include *Leghari v Pakistan*, in which the judge ordered the establishment of a Climate Change Commission to accelerate emission reductions, *Save Lamu v National Environmental Management Authority and Amu Power Co. Ltd* (Kenya), which invalidated the environmental impact assessment license for what would have been the first coal-fired power plant in East Africa, and the Colombian Supreme Court in *Future Generations v Ministry of the Environment and Others*, where the plaintiffs successfully argued that the state should develop and implement plans to reduce deforestation of the Colombian Amazon to protect children's constitutional rights to a healthy environment, life, health, nutrition and water, and the rights of future generations.

litigation,[2] and the discipline of climate change attribution was founded with the aim of providing evidence for then-putative lawsuits seeking to hold major emitters of greenhouse gases liable for climate change impacts.[3]

Despite these concurrent developments in the science and the law, few cases within the scope of our analysis have made successful claims for injury.[4] Previous work has found that the primary outcome-determinative obstacles preventing the success of climate litigation to date have been jurisdictional, justiciability-related and procedural rather than evidentiary,[5] which this work does not challenge. However, our analysis shows that major evidentiary challenges persist which have prevented courts from finding greenhouse gas emitters liable for climate damages, or from compelling defendants to reduce their emissions to avoid future climate change impacts. Put simply: plaintiffs have often provided inadequate evidence on causation and improved scientific evidence has a clear role to play if the courts are to accept causal arguments in future lawsuits. These evidentiary obstacles could be surmounted by (1) bringing cases pertaining to harms that are demonstrably attributable to climate change, (2) providing high-quality and specific scientific evidence on the role of climate change in losses, and (3) more effective use of scientific evidence in legal argumentation.

To improve the prospects of climate litigation we identify key lessons from an evaluation of the use of evidence in past and pending lawsuits, how scientific evidence could be developed to best support these cases, and how litigants can most effectively deploy the scientific evidence available to them. Our analysis covers 73 cases from 14 national jurisdictions. Cases were selected based on a systematic review of the Sabin Center for Climate Change Law's climate litigation database, and a review of cases cited in relevant academic literature. We considered the scientific evidence provided by plaintiffs and defendants in past climate-related lawsuits and how courts have interpreted this evidence. We supplement this analysis with a discussion

[2] Sophie Marjanac and Lindene Patton, 'Extreme Weather Event Attribution Science and Climate Change Litigation: An Essential Step in the Causal Chain?', *Journal of Energy & Natural Resources Law*, 36.3 (2018), 265–98 <https://doi.org/10.1080/02646811.2018.1451020>.

[3] Myles R. Allen, 'Liability for Climate Change', *Nature*, 421 (2003), 891–92; Myles R. Allen and others, 'Scientific Challenges in the Attribution of Harm to Human Influence on Climate', *University of Pennsylvania Law Review*, 155.6 (2007), 1353–1400.

[4] E.g., *Friends of the Irish Environment v The Government of Ireland & Ors* [2020] IESC 49, *Urgenda Foundation v The State of the Netherlands* (ECLI:NL:HR:2019:2007), *Ashgar Leghari v Federation of Pakistan* (2015) W.P. No. 25501/2015, *Future Generations v. Ministry of the Environment and Others* (2018) STC4360-2018, *AD Tuvalu* [2014] NZIPT 501370-371, *In re Greenpeace Southeast Asia and Others*, Case No. CHR-NI-2016-0001.

[5] Michael Burger, Radley M Horton, and Jessica Wentz, 'The Law and Science of Climate Change Attribution', *Columbia Journal of Environmental Law*, 45.1 (2020), 57–241 <https://doi.org/10.7916/cjel.v45i1.4730>.

of developments in scientific methodology and legal argumentation that could support these cases.

This briefing paper is targeted primarily at legal practitioners and overviews climate change attribution science (section 2) and the theories of legal causation applied across civil and common-law jurisdictions which underpin the interpretation of scientific evidence by the courts, drawing on detailed analysis of U.S., English, and German law, and extending our assessment through a comparative analysis of other jurisdictions (section 3). We then summarise key lessons from analogous toxic tort cases (section 4) and the key scientific (section 5) and legal (section 6) findings from a detailed analysis of the use and interpretation of attribution science evidence in case law. Finally, we provide a set of recommendations for the community of practice (section 7).

2. Using attribution science evidence in climate litigation

Scientific evidence may be introduced to a case in the form of testimony (of court-appointed experts or expert witnesses for the plaintiffs or defendants), documentary evidence (distinct from oral testimony and submitted in the form of documents), and physical evidence. It may appear in court filings, including complaints, and in amicus briefs submitted by third parties. There is a cross-jurisdictional tendency to ascribe value to authoritative sources of evidence such as peer-reviewed journal publications or Intergovernmental Panel on Climate Change (IPCC) reports.[6]

Establishing a causal relationship in law between a defendant's greenhouse gas emissions and the events that resulted in plaintiffs' losses requires interpreting scientific evidence through the lens of legal reasoning. The scientific evidence that demonstrates the causal relationships in question in these lawsuits is provided by attribution science: a set of methods which use counterfactual inquiry to quantify the change in probability or intensity of weather or climate-related events that is attributable to human influence. Existing scientific methods can quantify the contribution of greenhouse gas emissions to specific events, including (i) individual extreme events, such as storms, droughts, heatwaves, or floods,[7] (ii) long-term trends in glacier lengths or sea levels ('slow-onset events'), and (iii) persistent changes, for instance in mean temperatures or precipitation.

[6] Maria Lee, 'The Sources and Challenges of Norm Generation in Tort Law', *European Journal of Risk Regulation*, 9.1 (2018), 34–47 <https://doi.org/10.1017/err.2017.76>.

[7] E.g. Stephanie C. Herring, Nikolaos Christidis, Andrew Hoell, and others, 'Explaining Extreme Events of 2017 from a Climate Perspective', *Bulletin of the American Meteorological Society*, 100.1 (2019), S1–117 <https://doi.org/10.1175/BAMS-ExplainingExtremeEvents2017.1>; Stephanie C. Herring, Nikolaos Christidis, A. Hoell, and others, 'Explaining Extreme Events of 2016 from a Climate Perspective', *Bulletin of the American Meteorological Society*, 99.1 (2018), S1–157 <https://doi.org/10.1175/BAMS-D-17-0118.1>.

Attribution science is uniquely well equipped to serve as the evidentiary basis for litigation concerning the impacts of climate change. Nevertheless, in common with most types of scientific evidence, litigants must be cognisant of certain characteristics of attribution evidence that affect its use and interpretation by the courts.

i. Attribution is multi-factorial.

Climate change impacts result from human influence on the climate adding to the underlying chance that the event occurs due to natural factors. Further, impacts on human societies are mediated by societal vulnerabilities and exposures to physical climate change impacts. Recent scientific advances render attributing physical climate impacts to emitters comparatively straightforward.[8] However, scientifically attributing societal impacts (economic and non-economic losses) is more challenging[9] and has only recently become possible.[10]

ii. Attribution is often probabilistic.

While climate change increases the probabilities or intensities of many extreme weather events, in many cases an event might still have occurred even in the absence of human greenhouse gas emissions. Standards of proof for causation differ between law and science. Scientific causation is established through an assessment of the extent to which a factor has altered the event's probability or intensity. In most jurisdictions, legal causation comprises a counterfactual test to establish the 'actual cause', supplemented by tests involving normative considerations. Jurisdictions adopt various rules concerning the onus and standards of proof exist across jurisdictions.[11] Standards of legal proof for probabilistic evidence may also differ from the likelihoods evaluated in scientific assessments.[12] Scientific assessments will be of greatest use to courts if they provide evidence in line with the standards of proof required for legal causation.

[8] Sjoukje Philip, Sarah Kew, and others, 'A Protocol for Probabilistic Extreme Event Attribution Analyses', *Advances in Statistical Climatology, Meteorology and Oceanography*, 6.2 (2020), 177–203 <https://doi.org/10.5194/ascmo-6-177-2020>.

[9] Kristie L. Ebi and others, 'Using Detection And Attribution To Quantify How Climate Change Is Affecting Health', *Health Affairs*, 39.12 (2020), 2168–74 <https://doi.org/10.1377/hlthaff.2020.01004>.

[10] David J. Frame, Suzanne M Rosier, and others, 'Climate Change Attribution and the Economic Costs of Extreme Weather Events: A Study on Damages from Extreme Rainfall and Drought', *Climatic Change*, 162.2 (2020), 781–97 <https://doi.org/10.1007/s10584-020-02729-y>; Friederike E. L. Otto, Luke J Harrington, and others, 'Toward an Inventory of the Impacts of Human-Induced Climate Change', *Bulletin of the American Meteorological Society*, 101.11 (2020), E1972–79 <https://doi.org/10.1175/BAMS-D-20-0027.1>.

[11] Petra Minnerop and Friederike E. L. Otto, 'Climate Change and Causation: Joining Law and Climate Science on the Basis of Formal Logic', *Buffalo Environmental Law Journal*, 27 (2020), 49–86.

[12] Marjanac and Patton.

The law has also developed means of holding defendants responsible for probabilistic changes in an event's likelihood and for instances where individual defendants have only made a partial contribution to the event's occurrence.[13] Both of these considerations hold true for climate change impacts. Within jurisdictions, different standards of proof may be used to assess probabilistic causal claims in different settings. These are explored in detail for the US, UK, and Germany in section 3.

iii. Evidence is novel, rapidly developing, and, in common with all scientific evidence, subject to uncertainties.

Attribution assessments use a range of statistical and probabilistic methods to assess confidence in results and therefore the magnitude of uncertainty, as is standard practice in a range of scientific disciplines.[14] Sources of uncertainty include reliance of attribution evidence on imperfect model representations of the climate system and imperfect climatic observations for evaluating models' performance, particularly with respect to a model's reproduction of the counterfactual climate, absent human greenhouse gas emissions.

Further, attribution science is comparatively novel and rapidly developing. Consequently, there is currently limited precedent for attribution science evidence being accepted as substantiating causal links in the courts.

iv. The findings of attribution studies are often question-dependent.[15]

In common with many forms of expert evidence, results can be heavily influenced by the choice of event definition and multiple approaches to conducting attribution assessments may produce differing results despite being equally valid from a scientific point of view. Methodological standardisation[16] and the development of frameworks for assessing human influence on climate change impacts, such as health, may address this concern.

v. Greenhouse gases are fungible.

Harm results from the sum of emissions from multiple parties irrespective of where, or, for weather events, when they were emitted. This underlies the use of 'market share theory' for

[13] Marjanac and Patton; Minnerop and Otto.

[14] Sjoukje Philip, Sarah F. Kew, and others, 'Attribution Analysis of the Ethiopian Drought of 2015', *Journal of Climate*, 31.6 (2018), 2465–86 <https://doi.org/10.1175/JCLI-D-17-0274.1>.

[15] Otto, Harrington, and others.

[16] Philip, Sarah Kew, and others.

allocating liability.[17] According to this method, where the loss is attributable to climate change – i.e., greenhouse gas emissions as a whole – each tonne of greenhouse gas emissions is given equal weight irrespective its source, and an emitter's contribution to attributable harms is equal to the portion of emissions for which they are responsible (see section 4 for discussion of use of market share theory in toxic tort litigation).

It is recognised that this simplistic allocation approach may not exactly reflect defendant's contribution to losses which result from certain impacts, for instance, those which display threshold effects, such as coral reefs' response to ocean acidification. Emissions increase the magnitude of such impacts until a threshold is reached and further emissions cause no additional harm.[18] In such cases, actors' liability for impacts would only extend to the market share of emissions produced until the threshold was reached. Further, slow-onset (such as glacial retreat or sea-level rise) climate change impacts emerge over decades and respond only gradually to emissions. This can be accounted for in attribution analyses.[19]

The above-detailed characteristics are not unique to attribution science. Similar issues arise in most branches of scientific inquiry and are addressed by litigants and courts with argumentation and evaluation of evidence through causation tests (section 3). Taking these characteristics as an obstacle to establishing causation, is as much a consequence of the politicised framing of climate science as it is innate to the science itself.

The potential influence of attribution science in climate litigation was first elicited in the US Supreme Court ruling in *Massachusetts v EPA*, which found that the plaintiff had legal standing to bring a claim due to scientific evidence linking climate change and inundation of coastal land for which the state has a public trust responsibility.[20] By contrast, inadequate causal evidence has been an obstacle to the success of a range of climate-related lawsuits, starting from *Native Village of Kivalina v Exxonmobil Corporation*. In *Kivalina*, the US District Court for the Northern District of California's dismissal of the plaintiff's claim derived, in part, from the plaintiff's failure to establish standing through demonstrating causation.[21] This was the result of Kivalina's

[17] Marjanac and Patton. See Section 4 for detail on applications of market share liability in the context of toxic tort litigation.

[18] Luke J. Harrington and Friederike E. L. Otto, 'Adapting Attribution Science to the Climate Extremes of Tomorrow', *Environmental Research Letters*, 13 (2018), 123006 <https://doi.org/10.1088/1748-9326/aaf4cc>.

[19] R F Stuart-Smith and others, 'Increased Outburst Flood Hazard from Lake Palcacocha Due to Human-Induced Glacier Retreat', *Nature Geoscience*, 14.2 (2021), 85–90 <https://doi.org/10.1038/s41561-021-00686-4>.

[20] Sabrina McCormick and others, 'Science in Litigation, the Third Branch of U.S. Climate Policy', *Science*, 357.6355 (2017), 979–80 <https://doi.org/10.1126/science.aao0412>.

[21] Brian J Preston, 'The Influence of the Paris Agreement on Climate Litigation: Causation, Corporate Governance and Catalyst (Part II)', *Journal of Environmental Law*, 2020, 1–32 <https://doi.org/10.1093/jel/eqaa021>; *Native Village of Kivalina v Exxonmobil Corporation,* 663 F. Supp. 2d 863 (N.D. Cal. 2009).

failure to demonstrate a 'substantial likelihood' that the fossil fuel company defendants were responsible for Kivalina's injuries.[22] Attribution science evidence would have allowed the *Kivalina* plaintiffs to provide clear causal evidence that might have satisfied these two obstacles to establishing causation.

3. Causality across jurisdictions

Causation theories and tests are universal in some respects and jurisdiction-specific in others. Causation in law is established by assessing the scientific basis for a causal relationship, through the lens of legal reasoning. The legal tests and theories used to establish causation vary between jurisdictions. In this section we present analyses of causation in U.S., English and German law, and supplement them with a comparative analysis of how applicable these findings are to other jurisdictions.

Causation in U.S. law

Under U.S. law, causation is one of four essential elements for establishing a negligence claim[23]. It consists of two stages of analysis: cause in fact and proximate cause. The first stage of analysis, cause in fact, is also referred to as "actual causation",[24] "factual causation",[25] "the 'but for' test", "the substantial factor test",[26] and "the *sine qua non* test"[27]. It requires that a plaintiff show a link between the defendant's negligent behaviour and the plaintiff's injury. The test most commonly used to establish such a link is the "but for" test which asks "[b]ut for the defendant's negligent behaviour, would the plaintiff's damages have occurred?"[28] This legal test is scientifically equivalent to assessing the marginal contribution of a defendant's emissions to a given impact on the plaintiff, which has been quantified in past attribution

[22] Elizabeth Fisher, Eloise Scotford, and Emily Barritt, 'The Legally Disruptive Nature of Climate Change', *The Modern Law Review*, 80.2 (2017), 173–201 <https://doi.org/10.1111/1468-2230.12251>.

[23] Luke Meier, 'Using Tort Law to Understand the Causation Prong of Standing', *Fordham Law Review*, 80.3 (2011), 1241–99 <https://ir.lawnet.fordham.edu/flr/vol80/iss3/11> [accessed 16 April 2020].

[24] *See* Richard W. Wright, *Causation in Tort Law*, 73 CALIF. L. REV. 1735, 1813 (1985) (using the term "actual causation").

[25] *See generally* Arno C. Becht & Frank W. Miller, The Test of Factual Causation in Negligence and Strict Liability Cases (1961) (using the term "factual causation").

[26] *See* Restatement (Third) of Torts: Liab. for Physical & Emotional Harm § 26 reporters' note on cmt. j (2005) ("[T]he substantial-factor test can be useful because it substitutes for the but-for test in a situation in which the but-for test fails to accomplish what the law demands.").

[27] *See* Kenneth S. Abraham, The Forms and Functions of Tort Law 105–07 (3d ed. 2007) (explaining the process by which the jury is expected to make the cause in fact determination).

[28] *See* Restatement (Third) of Torts: Liab. for Physical & Emotional Harm § 26 cmt. a (2005).

studies.[29] The burden of proof falls on the plaintiff who must show, by a "preponderance of the evidence", that it is more likely than not that the plaintiff's injuries would not have occurred if the defendant had not breached a duty of care. The second stage of causation analysis, proximate cause, is also referred to as "legal cause",[30] "scope of liability",[31] and "risk standard". It assumes that the defendant's behaviour was a cause in fact of the plaintiff's injuries and considers whether the defendant should nevertheless be shielded from liability. The limiting function of this two-stage causation analysis is achieved through the application of a variety of tests, including "foreseeability" or "scope of the risk"[32], to determine whether the harms suffered by the plaintiff as a result of the defendant's negligent actions were sufficiently foreseeable at the time of the actor's tortious conduct.[33]

Causation in English law

As in U.S. law, in English law the starting point for thinking about causation in the climate context is the "but for" test. The test is satisfied if the evidence establishes, on the balance of probabilities, that but for the defendant's wrong, the plaintiff would not have suffered the harm would not have been observed. Also consistent with U.S. law, the causal link may be severed by an intervening cause, or by a subsequent action or event that severs the link between the harm suffered by the plaintiff and the defendant's wrongdoing [34]. Moreover, even if there is no break in the chain of events leading to injury, particular kinds of damage might be unrecoverable because they constitute a kind of damage of a kind that is not reasonably foreseeable or that is too remotely related to the defendant's actions.[35]

[29] Friederike E. L. Otto, Ragnhild B. Skeie, and others, 'Assigning Historic Responsibility for Extreme Weather Events', *Nature Climate Change*, 7.11 (2017), 757–59 <https://doi.org/10.1038/nclimate3419>; R Licker and others, 'Attributing Ocean Acidification to Major Carbon Producers', *Environmental Research Letters*, 14.12 (2019), 124060 <https://doi.org/10.1088/1748-9326/ab5abc>; B. Ekwurzel and others, 'The Rise in Global Atmospheric CO2, Surface Temperature, and Sea Level from Emissions Traced to Major Carbon Producers', *Climatic Change*, 144.4 (2017), 579–90 <https://doi.org/10.1007/s10584-017-1978-0>.

[30] Marshall v Nugent, 222 F.2d 604, 610 (1st Cir. 1955) (suggesting that "legal cause" and "proximate cause" are synonymous terms).

[31] Restatement (Third) of Torts: Liab. for Physical & Emotional Harm § 6 (using the term "scope of liability").

[32] *See* Abraham, *supra* note 29, at 124 ("Most cases posing the issue of proximate cause can be resolved by the foreseeability test or by a closely related elaboration, the harm- within-the-risk test."); *See* Robertson et al., *supra* note 24, at 172 (describing this approach as "what courts actually do" in "a significant number of cases" despite employing various names for their tests).

[33] Restatement (Third) of Torts: Liab. for Physical & Emotional Harm s 29 (3rd 2010).

[34] Deakin and Markesinis, ibid, 225 *et seq.*

[35] ibid, 231 *et seq;* Clerk and Lindsell on Torts, 23rd ed, [2-06].

Even where the but for test is not met, causation may still be established under English law using arguments of "material contribution to harm" or "material contribution to the risk of harm".[36] Under current law, "material contribution to the risk of harm" is thought to be available only where a "single agent" is implicated in the relevant causal process and where there is a "rock of uncertainty"[37] such that "causation is impossible to prove *in principle*".[38] Notably, the current state of attribution science refutes such impossibility, and, accordingly, "material contribution to harm" is most relevant to our purposes. The premise of the material contribution to harm cases is that it *is* possible to show that the defendant's conduct made a contribution to the causal process that produced the plaintiff's harm,[39] *and* that it is established on the balance of probabilities that this contribution was more than trivial.[40] The test responds to fact patterns where it is not possible to establish the proportion of the defendant's contribution on the balance of probabilities[41] because the resulting harm is indivisible, or where "the injury is divisible in principle" but "it is not possible to attribute constituent parts to particular factors on the facts of a given case".[42] For most climate change impacts, however, an individual defendant's proportional contribution can be determined. On the current state of the law, it appears that attribution science may be relied on in climate-related litigation with a view to establishing that a defendant materially contributed to the claimant's harm, provided that it can be said that they have made a contribution to the causal process that produces the relevant harm.[43]

Causation in German law

Under the German Civil Code, the core causation test comprises two stages of analysis: liability-grounding and liability-fulfilling causation.[44] A judge determines whether liability-grounding causation exists, based on the evidence provided and in accordance with their own

[36] See further Sarah Green, *Causation in Negligence* (Hart, 2017) Chs 5-6.

[37] Lord Bingham's language in *Fairchild v Glenhaven Funeral Services* [2003] 1 A.C. 32, [7].

[38] Green, nx, 123, 126.

[39] See *Heneghan*, [46]: "That test is to be applied where the court is satisfied on scientific evidence that the exposure for which the defendant is responsible has in fact contributed to the *injury*".

[40] ibid, [45].

[41] Consistently with this, see Green, nx, 95.

[42] ibid, 94.

[43] It follows from this that the doctrine will not be available where the harm could have been caused by any of a number of competing causes: *Wilsher*.

[44] MÜNCHNER KOMMENTAR, *supra* note 43, at § 249; GERVEN, *supra* note 21, at 396.

conviction.[45] Achieving the necessary standard of proof requires that a level of certainty is reached, 'which silences doubts for practical purposes even if not eliminating them fully'.[46] However, that does not mean that judges may arrive at a merely subjective personal opinion; rather, they must follow a standard of rationality which is defined by the content of the hearings and the evidence.[47] Specific to the German context, a theory of adequate causation was developed in the literature and is widely used by the courts. Adequate causation eliminates causal relationships which are determined to be unlikely from the perspective of an objective bystander and comprises a probabilistic determination on liability. English and German tort law seem to differ with respect to whether an omission can fail the but for test but still succeed as a cause of injury. Evidence for causation presents a main hurdle for claimants, especially in cases like *Lluiya* where the aim of the claim is to hold a carbon major to account for a particular climate impact.

Comparative Analysis

In jurisdictions that follow the two-stage causation analysis (as is the case in the U.S., England, and Germany) scientific evidence is most relevant to the first stage of causation analysis, factual causation or general causation, while legal principles are most relevant for the second stage of analysis, legal causation. At the second stage of causation analysis, seven common legal tests for causation have been identified.[48] In continental European jurisdictions, adequacy, foreseeability, scope of the norm, scope of the risk, and proximity are commonly observed. In common law jurisdictions, remoteness is commonly considered. In European as well as common law jurisdictions, interruption of the chain of causation is adopted.

While jurisdictions differ with respect to the tests used for evaluating causal claims, climate litigants confront common difficulties when meeting the varying thresholds for establishing causation found in different jurisdictions. The required standard of proof varies considerably between jurisdictions. The U.S., England, Ireland, Denmark, and Lithuania adopt a "more probable than not" standard, Austria and the Netherlands adopt a "high probability" and

[45] §286 ZPO Evaluation of evidence at the court's discretion and conviction: (1) The court is to decide, at its discretion and conviction, and taking account of the entire content of the hearings and the results obtained by evidence being taken, if any, whether an allegation as to fact is to be deemed true or untrue. The judgment is to set out the reasons informing the conviction of the judges.

(2) The court shall be bound to statutory rules of evidence only in the cases designated in the present Code. Available at https://www.gesetze-im-internet.de/englisch_zpo/englisch_zpo.html#p1067 (last accessed 5 November 2020).

[46] BGHZ 53, 245, 256.

[47] The General Burden of Proof, Causal Concepts, 55.

[48] Marta Infantino and Eleni Zervogianni, *Causation in European Tort Law*, *Causation in European Tort Law* (Cambridge: Cambridge University Press, 2017) <https://doi.org/10.1017/9781108289887>.

"reasonable degree of certainty" standard, respectively. Most continental European jurisdictions, by contrast, adopt a higher standard of proof: in Germany it is a near certainty standard, in Bulgaria and Spain certainty is expected, in Greece, France, Poland, and Italy a judge must be convinced that the causal link exists.[49] While the standard of proof is formulated differently across jurisdictions, it may be difficult to ascertain where it is, in practice, more or less stringent.

Previous research has argued that causation in law assesses the factors which act to produce an event. Specifically, the factors considered to be a cause of an event must have, at minimum, increased the *probability* of the event's occurrence in a statistically significant way.[50] While there are no established normative correctives in climate litigation, a coherent causal analysis requires re-thinking the fundamental normative assumptions (which would then also capture the existing exemptions from the 'but for' test). Previous scholarship has sought to address the lack of agreement on normative correctives in climate litigation by arguing that causal explanations for climate change impacts can be developed through demonstrating greenhouse gas emissions to be a necessary, sufficient, or sustaining (i.e. maintaining an effect) cause.[51] This would allow for a coherent causal analysis even in cases where the judiciary takes recourse to normative considerations to avoid placing the financial burden on those who have suffered the injury.

4. Findings from toxic tort cases

Toxic tort and product liability case law offers lessons for climate litigation case theory and strategy. In toxic tort and product liability lawsuits, as in climate litigation, scientific evidence is an important element of establishing general and specific causation. Furthermore, the epidemiological evidence, which is central to establishing general and specific causation in such cases, shares some important features with climate attribution evidence. Epidemiological studies attempt to determine whether an association exists between a particular disease and a factor suspected of causing it.[52] Both epidemiological and climate attribution methodologies consist of probabilistic, counterfactual analyses. For example, in some jurisdictions (e.g. California), the "more likely than not" standard is considered met and causation is established

[49] Infantino and Zervogianni, pp. 611–12.

[50] Minnerop & Otto, STREVENS, *supra* note 4, at 7, 8.

[51] Minnerop and Otto.

[52] *See Cook v. United States*, 545 F. Supp. 306, 308 (N.D. Cal. 1982) ("Whenever the relative risk to vaccinated persons is greater than two times the risk to unvaccinated persons, there is a greater than 50% chance that . . . [the harm] . . . among . . . [exposed individuals] . . . is attributable to vaccination, thus sustaining plaintiff's burden of proof on causation.")..

if a specific factor is shown to have at least doubled the probability of an individual's disease.[53] In the case of *Merrel Dow v. Havner*, the Supreme Court of Texas elaborated a rationale for this probabilistic standard, explaining that "[s]uch a theory concedes that science cannot tell us what caused a particular plaintiff's injury" and that "[i]t is based on a policy determination that when the incidence of a disease or injury is sufficiently elevated due to exposure to a substance, someone who was exposed to that substance and exhibits the disease or injury can raise a fact question on causation".[54] The successes of epidemiological evidence in establishing a statistical alternative to traditional causation tests offer some guidance for leveraging climate attribution science to establish specific causation in climate litigation.

Another notable similarity between toxic tort/product liability cases and climate litigation, is the difficulty of attributing the source of a plaintiff's specific exposure to one of many potential defendants who all produce the same product.[55] In drug product liability case law, courts have adopted a "market share liability" theory to address this particular challenge. Market share liability first appeared in the case *Sindell v. Abbott Laboratories*.[56] In that case, a number of companies produced the drug alleged to cause injury and plaintiffs could not ascertain which company produced the drug causing the harm. As a consequence, plaintiffs could not attribute their harm to a particular manufacturer. Market share theory allowed courts to apportion damages among a group of defendants, and to hold each defendant liable for the proportion of the judgment represented by its share of the product market.[57] In *Sindell*, the court noted that in light of the difficulty of apportioning damage under such circumstances, a market share theory offered a pragmatic solution, "where a correct division of liability cannot be made the

[53] See, e.g., *Daubert v. Merrell Dow Pharm., Inc*., 43 F.3d 1311, 1320 (9th Cir. 1995) ("[P]laintiffs must establish not just that their [exposure to the drug in question] increased somewhat the likelihood of [injury], but that it more than doubled it—only then can it be said that [the drug] is more likely than not the source of their injury."); *In re Bextra & Celebrex Mktg. Sales Practices & Prod. Liab. Litig*., 524 F. Supp. 2d 1166, 1172 (N.D. Cal. 2007) (Establishing that a relative risk greater than 1.0 establishes general causation "that exposure to the agent is capable of causing [the illness at issue] in the general population" and that a relative risk greater than 2.0 may establish specific causation, that "the product more than doubles the risk of getting the disease."

[54] *Merrell Dow Pharm., Inc. v. Havner*, 953 S.W.2d 706, 715 (Tex. 1997).

[55] The dose-response relationship is used to evaluate whether an alleged exposure caused a specific harm. See, e.g., *In re Denture Cream Prods. Liab. Litig.*, 795 F. Supp. 2d at 1351-52. This stands opposite to the "every exposure theory" that appeared in asbestos litigation and that has largely been dismissed by the courts because it "lacks sufficient support in facts and data". *See, e.g*., *Vedros v. Northrop Grumman Shipbuilding, Inc*., 119 F. Supp. 3d 556, 562 (E.D. La. 2015) ("The every exposure theory "represents the viewpoint that, because science has failed to establish that any specific dosage of asbestos causes injury, every exposure to asbestos should be considered a cause of injury.") (quotations omitted).

[56] 26 Cal. 3d 588 (1980).

[57] *Id.* at 612, 607 P.2d 924, 937 (1980)

trier of fact may make it the best it can."[58] It should be noted that the market share theory might not be directly transplanted to the greenhouse gas emissions context since it requires that defendants constitute "substantially all" of the market. While the drug manufacturers responsible for a particular drug might be readily identified, the large number of greenhouse gas emitters makes it infeasible to address "substantially all" of the market for greenhouse gas emissions. However, such an innovation models how novel legal theories might be devised to pragmatically address the unique challenges of climate attribution.

5. Scientific analysis: key findings

i. While ¼ of analysed cases referred to attribution science studies, **very few cases provided peer-reviewed attribution science evidence linking defendants' emissions to plaintiffs' alleged damages**. The absence of high-quality evidence of this type is a fundamental obstacle to establishing causation in the courts. This omission has been cited explicitly or implicitly by courts in multiple jurisdictions and exploited by defendants in their responses to complaints. Despite a promising trend of increasing reference to peer-reviewed evidence in damages claims, **it remains the case that the quality of the scientific evidence used in most climate-related lawsuits is generally lower than that which is required to establish causation before the courts**.

ii. **A significant number of cases concern hard-to-attribute impacts**, such as hurricane-related damages, or regional sea level rise impacts. Closer collaboration between scientists and lawyers in preparing cases should ensure that claims concern impacts that are demonstrably attributable to climate change.

iii. **The quality of causal evidence provided in past climate litigation lags behind the state of the art in attribution science**, and climate science in general. Recent developments in attribution science allow studies to encompass the full causal chain from emissions to the impacts experienced by human societies (so-called 'end-to-end' or 'impact' attribution)[59] rather than the physical impacts alone (e.g., the heatwave or storm).

[58] *Id.* at, 612–13.

[59] Dáithí A. Stone and Myles R. Allen, 'The End-to-End Attribution Problem: From Emissions to Impacts', *Climatic Change*, 71.3 (2005), 303–18 <https://doi.org/10.1007/s10584-005-6778-2>; Daniel Mitchell and others, 'Attributing Human Mortality during Extreme Heat Waves to Anthropogenic Climate Change', *Environmental Research Letters*, 11.7 (2016), 074006 <https://doi.org/10.1088/1748-9326/11/7/074006>; Sebastian Sippel and others, 'Warm Winter, Wet Spring, and an Extreme Response in Ecosystem Functioning on the Iberian Peninsula', *Bulletin of the American Meteorological Society*, 99.1 (2018), S80–85 <https://doi.org/10.1175/BAMS-D-17-0135.1>; David J. Frame, Michael F Wehner, and others, 'The Economic Costs of Hurricane Harvey Attributable to Climate Change', *Climatic Change*, 160.2 (2020), 271–81 <https://doi.org/10.1007/s10584-020-02692-8>.

iv. Attribution claims in cases analysed could be easily rebutted by defendants. **Direct causal relationships between climate change and plaintiffs' losses were presumed to exist by plaintiffs in the majority of cases, rather than demonstrated using scientific evidence**.[60] Plaintiffs infrequently provided thorough assessment of the various drivers of harm in causal claims. This omission exposes them to responses from defendants that seek to diminish the responsibility of climate change for losses by emphasising the role of natural variability, or plaintiffs' vulnerabilities or other drivers in causing the loss. Plaintiffs should seek evidence substantiating these alleged causal links from the scientific community.

v. **Courts have repeatedly found that plaintiffs have failed to demonstrate that defendants' emissions contributed to the alleged impacts**. In response, plaintiffs could use attribution evidence quantifying the marginal contribution made by defendants' emissions to losses. The marginal contribution is defined here as the difference in the impact that would have occurred if not for a certain actor's emissions.

vi. **The scientific evidence provided is uneven in quality along the causal chain.** Claims seeking financial compensation for the costs of measures taken to adapt to the impacts of climate change have generally been supported by robust scientific evidence demonstrating that hazards threaten plaintiffs and therefore that the adaptation measures were indeed necessary. However, the evidence needed to establish a causal link between defendants' actions and the impacts affecting plaintiffs would need to be much stronger than that which is found in existing case law.

vii. In cases where plaintiffs seek relief in the form of emission reductions from defendants, courts have dismissed claims on the grounds that **plaintiffs failed to demonstrate how the requested emissions reduction would materially affect alleged climate impacts**. Methodologies similar to those used in attribution science could be used to demonstrate the projected consequence of the requested emission reductions. Courts have denied claims due to plaintiffs' failure to prove that climate change impacts could be attributed to the inadequate ambition of the state's emission reduction targets.[61]

[60] For example, in *City and County of Honolulu*, the complaint states that 'The City has already incurred damages as a direct and proximate result of Defendants' conduct, including … flooding and intense runoff during rain bomb events [that] has destroyed sections of the City's drainways normally used to divert rainfall away from populated areas … The City incurred significant costs … during a massive rain bomb in April 2018 … providing emergency response'. *City and County of Honolulu v Sunoco LP et al*, 1CCV-20-0000380 (Hawai'I Cir.Ct. 2020), para 151.

[61] E.g., *Sinnok et al. v State of Alaska et al., No. 3AN-17-09910 CI (Alaska Super. Ct. 2018).*

6. Legal analysis: key findings

i. Courts have adopted varying tests for causation in different jurisdictions. These tests define a range of thresholds for liability, and some have been applied with more flexibility than others. While it is difficult at this stage to identify clear jurisdictional differences in the stringency of the causation tests applied by the courts, **'fair traceability'-type tests have shown more promise in establishing standing** than tests requiring that plaintiffs demonstrate how the losses they have experienced would have changed 'but for' defendants' emissions.

ii. **Courts generally accept plaintiffs' arguments establishing a general causal relationship between defendants' greenhouse gas emissions and climate change**. This satisfies the first element of the courts' causation analysis.

iii. **The greatest obstacles to establishing causation concern specific causation**. Both defendants and judges have challenged plaintiffs' claims that defendants' greenhouse gas emissions caused the losses alleged in complaints. Even if the link between greenhouse gas emissions and climate change, in general, is accepted, challenges have concerned whether the emissions of the defendant(s) alone made a material contribution to climate change, and the link between climate change and the specific impact alleged (e.g., the hurricane / flood, etc.).

iv. **In the majority of cases analysed, the evidentiary gaps identified by courts could be filled with attribution science evidence developed using existing methods.**

v. Where a court's analysis considers the defendant's marginal ('but for') contribution to the plaintiff's alleged losses, **challenges to establishing liability will remain.** This is especially the case where **defendants' contribution to plaintiffs' losses is much lower when assessing their marginal, rather than market-share, contribution**.

vi. Plaintiffs' failure to demonstrate that losses were a foreseeable consequence of defendants' actions presents an obstacle to successful damage liability suits. While foreseeability was established in some cases,[62] in most cases in which this was discussed, courts have determined that **defendants could not have reasonably foreseen damages because their emissions are negligible when compared to global greenhouse gas emissions that resulted in the harms alleged, or when the chain of events that plaintiffs claim will occur is speculative**. By connecting impacts to emissions, attribution science can support claims that damages are indeed reasonably foreseeable.

vii. Understanding **the relationship between plaintiffs' vulnerability and exposure to climate-related hazards may be necessary when discerning responsibility for harm**.

[62] E.g., *St. Bernard Parish Government v United States, 121 Fed. Cl. 687 (Ct. Cl. 2015)*

These factors have been largely overlooked in past cases, with the exception of human rights litigation. Consequently, the significance of this issue for climate litigation cannot yet be fully understood but it is an area that requires further investigation.

7. Recommendations for the community of practice

Based on the conclusions from our analysis, we offer recommendations for climate litigators. These recommendations support plaintiffs to overcome barriers to establishing causation and direct the scientific community to develop evidence that provides stronger support for claims.

i. Strengthen collaboration between the academic and practitioner communities.

The research described here has demonstrated the important role that climate science can play in lawsuits. Scientists can provide the strong evidence needed for courts to accept allegations of defendant responsibility for climate-related harms. Although providing scientific evidence which addresses outstanding obstacles to establishing causation is technically feasible, the evidence provided in recent litigation still lags considerably behind the state of the art in climate science. For instance, despite the fact that quantifying individual emitters' contributions to most climate change impacts is scientifically feasible, and the fact that some defendants' replies and courts' rejection of causal allegations would be addressed with evidence of this type, no plaintiffs have provided quantitative information on defendants' marginal contributions to climate damages.

Closer integration of and better dialogue between the legal and scientific communities would ensure that lawyers are aware of, and able to request and access the type of attribution evidence that can be used to robustly evaluate the causal claims brought before the courts. This could be achieved through: (1) effective education of the legal and scientific communities about how they can support one another; (2) coordination through the development of a database of independent scientists with expertise in attribution science and a good overview of scientific developments (e.g. IPCC authors), who would support practitioners in soliciting relevant evidence; and (3) dedicated funding streams that support the continued development of science in this field and enable practitioners to access research needed to make well-evidenced claims. Cross-community understandings of the legal significance of peer-reviewed literature as an authoritative form of evidence should also be fostered. Lawyers also need to make the scientific community aware of the types of evidence that are most effective to establish causation in the courts.

ii. Learn lessons from non-climate cases.

Climate litigation strategy should continue to capitalise on analogous challenges overcome in relevant case law in developing case theory and strategy. We observe that toxic tort case law offers lessons for the effective incorporation of scientific evidence to establish general and specific causation. In toxic tort cases where scientific evidence has been outcome

determinative, there are transferrable lessons and strategies that would advance climate litigation strategies. The Roundup Product Liability Litigation, for example, provides a guide for successfully establishing causation where there is a "possibility that a plaintiff's harm suffered is attributable to an unknown cause."[63] Smoking-related lawsuits, such as In re Simon II Litigation, exemplify appropriate use of statistical data and other evidence in a context where there is mass injury. Asbestos-related cases offer lessons in determining legal causality even when multiple actors have made fungible contributions to injuries.[64]

iii. Inform the scientific community of the needs of litigators.

Courts across jurisdictions have noted that the quality of the evidence provided by plaintiffs substantiating causal links between defendants' greenhouse gas emissions and climate change, and between climate change and the specific harms suffered by plaintiffs, is inadequate. This finding takes two, related forms. First, in lawsuits seeking to hold defendants liable for climate damages, plaintiffs failed to demonstrate how defendants' emissions alter the impacts experienced. Secondly, in lawsuits seeking orders for emission reductions, courts have found evidence to be insufficient to show that the requested reduction in defendants' emissions would alleviate the harms that plaintiffs allege would otherwise occur. Scientific methodologies can advance claims of both types by quantitatively demonstrating the impact of defendants' greenhouse gas emissions on observed, or the likelihood of future, events.

iv. Pre-empt potential arguments of defendants.

Existing case law does not address vulnerability as a key consideration in plaintiffs' claims for damages resulting from emissions causing climate change. Aside from a Pakistani case, *Leghari*, and *In re AD (Tuvalu)*, an appeal to the New Zealand Immigration and Protection Tribunal, which recognised plaintiffs' vulnerability, we did not identify other cases where plaintiffs' vulnerabilities were acknowledged and accounted for when determining claims for damages. Incorporating vulnerability considerations presents one opportunity for future case development. With contribution from the scientific community, plaintiffs could disentangle the impact of climate change on plaintiffs' losses from those driven by other factors related to vulnerability and exposure. Critically, this would defend against allegations that plaintiffs' exposure or vulnerability to a hazard mitigates defendants' liability for climate impacts.

Challenges to holding emitters responsible for impacts exist when others, such as local or national governments, bear responsibility for managing communities' exposure and vulnerability to physical climate impacts, if their failure to do so increased the impacts on plaintiffs. There are legal paths to addressing this concern, but this also underlines the importance of the public law strategies in complementing private litigation approaches.

[63] In re Roundup Prod. Liab. Litig., 358 F. Supp. 3d 956 (N.D. Cal. 2019)

[64] Minnerop and Otto.

The eggshell skull plaintiff (U.S.) or the thin skull plaintiff (English law) rule[65] from tort common law doctrine establishes that a tortfeasor is liable for consequences arising from their tortious conduct that causes injury to another person, even if the victim suffers an unusual and/or unforeseeable level of damage due to pre-existing physical, social, or economic vulnerabilities. Transposing the eggshell skull doctrine into climate litigation could provide legal arguments that, complemented with scientific evidence, demonstrate the role played by climate change as the driver of harm for the plaintiff(s). This underlines the need for clear evidence supporting the establishment of factual causation and could serve as a resolution to defence strategies which seek to mitigate liability through emphasising plaintiffs' vulnerability or exposure to climate change impacts. To advance this strategy, research and consideration by practitioners is needed. This should cover the legal dimensions of such claims and scientific methodologies that can disentangle drivers of harm.

Further, effective collaboration between the scientific community and litigators will ensure that plaintiffs ensure that they avoid scientific inaccuracies which can be exploited by defendants. For instance, section 2(v) notes instances where quantifying a defendant's contribution to the impact according to their market share of historical greenhouse gas emissions may not reflect defendants' exact contributions to losses. As improved argumentation allows cases to proceed further through the courts and questions around causality become increasingly prominent, it is essential that plaintiffs' causal allegations are supported by scientific evidence and that plaintiffs pre-empt possible contradictory evidence that might be submitted by defendants.

v. Promote strategic publication and dissemination of scientific evidence establishing the foreseeability of harms from greenhouse gas emissions.

In some jurisdictions, harms must be foreseeable to the defendant if specific causation between defendant's act and plaintiff's injury is to be established. Scientific research demonstrating the foreseeability of the specific consequences of greenhouse gas emissions published in reputable journals and disseminated in popular media, would mainstream understanding of the foreseeability of injuries resulting from climate change caused by defendant emitters. Smoking, asbestos, and opioid litigation offer analogous examples of how to 'mainstream' particular scientific findings (smoking and asbestos exposure cause cancer, opioids are addictive) and how to leverage such findings to allow plaintiffs to meet foreseeability requirements for the harms they suffered. The Paris Agreement commitment for governments to provide clear communication on in-country climate change mitigation and adaptation needs could be another lever for disseminating and mainstreaming this knowledge.

[65] The term "eggshell skull" refers to a hypothetical person with a skull as delicate as an eggshell. In the paradigmatic example, a tortfeasor who injures the eggshell plaintiff is unaware of their condition and unexpectedly causes their skull to break. Under established doctrine, the tortfeasor is liable for all damages resulting from the wrongful contact, even if the severity of injury was greater than that which some other person in the shoes of the victim might have experienced.

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Additional information

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