

ARTICLE

Receding Glaciers, Advancing Law: The Imperative of Using Best Available Science in the Case of *Lliuya v. RWE* and Beyond

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Abstract

On 28 May 2025, the Higher Court of Appeal in Hamm (Germany) delivered a pioneering judgment in the case *Lliuya v. RWE*. The Court confirmed that German private nuisance law was applicable in the transnational context, and that the greenhouse gas emissions of the energy company RWE contributed to climate change and its adverse impacts. Based on the evidence provided, the Court concluded that the normative threshold of ‘imminence’ of a future, first-time property impairment was not reached. This article assesses the Court’s reasoning and the challenges it faced in determining ‘imminence’, considering conflicting scientific evidence. Against the backdrop of a legal and scientific analysis, the article argues that the physical laws underpinning climate change, and the scientific assessments of the Intergovernmental Panel on Climate Change, form a baseline of ‘best available science’ for the legal assessment of climate risks. Case-specific evidence that deviates from this baseline requires careful consideration. Furthermore, the legal interpretation of causally relevant evidence must depend on whether the science provides a qualitative or a quantitative statement.

Keywords: Climate litigation; Private nuisance law; Climate change; Glacial retreat; Glacial lake outburst flood; Causation and climate impacts

1. Introduction

On 28 May 2025, after ten years of litigation, the Higher Court of Appeal in Hamm (Germany) decided the case *Lliuya v. RWE*.¹ The Court did not permit the appeal to the Federal Court of Justice and, as the claimant decided not to file a complaint against

¹ *Saúl Ananías Luciano Lliuya v. RWE AG*, Oberlandesgericht Hamm (Germany), 28 May 2025, I-5 U 15/17 (*Lliuya v. RWE*). Translation of the German judgment by the authors; paragraph references are made to the official German version. A non-official English translation is available at: https://www.climatecasechart.com/documents/luciano-lliuya-v-rwe-ag-judgment_ceb4.

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the denial of leave to appeal, the judgment is final.² Winners and losers in any climate litigation are often difficult to discern from a legal perspective – if less so from an ethical standpoint – and both sides in these proceedings have claimed some sort of victory.³ Climate adjudication is ‘legally disruptive’⁴ and, even though the case was not decided in favour of the claimants, it shows a growing judicial awareness of the duties owed by large emitters in responding to the threat of climate change. The case illustrates the transnational scope of German private nuisance law; it demonstrates that it is scientifically and legally possible to find a causal link between the greenhouse gas (GHG) emissions of a large emitter and the impacts of climate change, and it draws further attention to the importance of concretizing the meaning of ‘best available science’ for the application of normative thresholds and legal concepts.

More specifically, the judgment shows how nuisance law under section 1004 of the German Civil Code⁵ can be situated in the response to the global threat of climate change. The purpose of this article is to use a novel methodology that employs a combined law and science analysis of the judgment to develop an argument that goes beyond the specific case and is more widely applicable: case-specific expert evidence must remain firmly connected with and anchored in the existing body of climate science where high confidence levels have been established, to support robust legal reasoning. Using the concept of climate causality, the article explains how a baseline for best available scientific evidence comprises the universal laws of physics, the reports of the Intergovernmental Panel on Climate Change (IPCC), and relevant evidence that – even if not yet reviewed by the IPCC – is aligned with the laws of physics and the IPCC reports.⁶

² Ibid., para. 138. According to s. 544(1) of the German Code of Civil Procedure, ‘such complaint is to be lodged with the court hearing the appeal on points of law within a statutory period of one (1) month following service of the fully worded ruling, at the latest, however, by the expiry of six (6) months after the judgment has been pronounced’: Zivilprozessordnung (German Code of Civil Procedure), 5 Dec. 2005, *Bundesgesetzblatt* (BGBl) 2006, I, p. 3202, official English translation available at: https://www.gesetze-im-internet.de/englisch_zpo/englisch_zpo.html#p2013.

³ On the groundbreaking significance of the judgment, see press release by environmental and human rights non-governmental organization (NGO) Germanwatch, ‘Bahnbrechendes Urteil in Klimaklage gegen RWE: Große Emittenten können für Klimarisiken haftbar gemacht werden’, 28 May 2025, available at: <https://rwe.climatecase.org/de/pressemitteilungen/artikel/bahnbrechendes-urteil-klimaklage-gegen-rwe-grosse-emittenten-koennen>. See also F.M. Klein & J. Peters, ‘New Era of Accountability’, *Germanwatch*, 2025, available at: <https://rwe.climatecase.org/sites/default/files/2025-06/New%20Era%20of%20Accountability%20EN.pdf>; U. Barth, ‘Freshfields Wins Landmark RWE Climate Case, but Legal Risks for Corporate Polluters Are Heating Up’, *Law.Com International*, 28 May 2025, available at: <https://www.law.com/international-edition/2025/05/28/freshfields-wins-landmark-rwe-climate-case-but-legal-risks-for-corporate-polluters-are-heating-up/?slreturn=20250625082742>.

⁴ E. Fisher, E. Scotford & E. Barritt, ‘The Legally Disruptive Nature of Climate Change’ (2017) 80(2) *The Modern Law Review*, pp. 173–201, at 178.

⁵ Bürgerliches Gesetzbuch (German Civil Code), 2 Jan. 2002, BGBl 2002, I, p. 42, official English translation available at: https://www.gesetze-im-internet.de/englisch_bgb/englisch_bgb.html.

⁶ E. Hill et al., ‘Twenty-First Century Response of Petermann Glacier, Northwest Greenland to Ice Shelf Loss’ (2021) 67(261) *Journal of Glaciology*, pp. 147–57; C. Stokes et al., ‘Warming of +1.5°C is Too High for Polar Ice Sheets’ (2025) 6 *Communications Earth & Environment*, article 351; J. Jordan et al., ‘The Sensitivity of Cook Glacier, East Antarctica, to Ice-Shelf Extent and Grounding-Line Position’ (2022) 68(269) *Journal of Glaciology*, pp. 473–85. See further Section 4.4.

Central to the argument is the legal treatment of uncertainties in relation to climate causality. While causation in the context of climate change has attracted scholarly discussion,⁷ this article closes a gap in clearly distinguishing between qualitative and quantitative causation in climate science, a distinction that will change the legal treatment of the uncertainties affecting changes in risks over certain periods of time, in cases such as *Lliuya*. It flows from our argument that for any deviation from the baseline of best available science (that is, evidence that directly or indirectly challenges, for example, existing IPCC assessments), not only is an additional scientific explanation warranted but also that the deviation will affect the confidence levels attached to the reported evidence. These confidence levels will inevitably change significantly as a result of the deviation. It resonates from the analysis that the presentation of evidence, and its subsumption within the concept of best available science, in a legal setting must evolve further to reposition and stabilize legal concepts and normative thresholds amidst the challenges of climate change.

This article proceeds in five sections. Section 2 turns to the discussion of German nuisance law and civil procedure law, and situates the case in the wider context of key developments pertaining to corporate duties in recent climate litigation. Section 3 analyzes significant legal developments derived from the judgment, and it critically evaluates the reasoning, including in respect of causation and the significance of RWE's contributions to climate change. Section 4 examines the normative threshold of 'imminent first impairment' from an integrated law/science perspective, and discusses the importance of using IPCC reports as a baseline for best available science in climate litigation. On that basis, Section 5 uses the concept of climate causality to delve deeper into the requirement to differentiate, in the legal assessment, between qualitative and quantitative statements about the causal quality of a factor, in the context of a specific impact of climate change.

The overarching objective is to dispel some persistent misunderstandings afflicting legal readings of climate science, such as the role of the past in informing future risks in a rapidly changing climate, with a view to prompting more interdisciplinary research to advance the engagement with scientific evidence for legal concepts such as causality, probability, and imminence. These concepts will have not only different peculiarities but also shared characteristics across jurisdictions. Ultimately, such research can forge the knowledge to pre-emptively design legal frameworks that address the human contribution to extreme weather events. Section 6 synthesizes the main findings and concludes.

⁷ S. Marjanac & L. Patton, 'Extreme Weather Event Attribution Science and Climate Change Litigation: An Essential Step in the Causal Chain?' (2018) 36(3) *Journal of Energy & Natural Resources Law*, pp. 265–98, at 267; P. Minnerop & F.E.L. Otto, 'Climate Change and Causation: Joining Law and Climate Science on the Basis of Formal Logic' (2020) 27(1) *Buffalo Journal of Environmental Law*, pp. 49–86; P. Minnerop, 'Climate Causality: From Causation to Attribution', in M. Wewerinke-Singh & S. Mead (eds), *Cambridge Handbook on Climate Change Litigation* (Cambridge University Press, 2025), pp. 415–44; L. Benjamin & S. Seck, 'Causation', in Wewerinke-Singh & Mead, *ibid.*, pp. 391–414; D. Faranda et al., 'A Climate-Change Attribution Retrospective of Some Impactful Weather Extremes of 2021' (2022) 3(4) *Weather and Climate Dynamics*, pp. 1311–40.

2. Employing Private Nuisance Law to Address the Risk of Receding Glaciers

Historically, private nuisance law has been concerned with the interference with another person's use or enjoyment of their land, often in the nearby neighbourhood.⁸ The Hamm Court has expanded on this traditional reading of nuisance law in a transnational context. It found that it can be possible to causally link the GHG emissions⁹ of one large emitter to a concrete risk of property damage in a country that is more than 5,000 miles away. The case before the Court involved a claimant from Peru and the energy provider RWE, a large company headquartered in Germany and responsible for large quantities especially of carbon dioxide (CO₂) as a result of extracting and selling fossil fuels, including coal, for the purpose of energy generation.¹⁰ The Court advanced the scope of private nuisance law in Germany's civil law system, a legal framework that differs from strict liability rules applicable in common law private nuisance claims, but also shares similarities in respect of the requirement of causality and thresholds such as significance of the causal contribution.¹¹

Under German nuisance law, the owner of a property can request the removal of a disturbance in line with section 1004(1) of the Civil Code. In addition, if there is an imminent threat of a repeated impairment ('further interferences'), the owner has the legal right to request the defendant (the 'disturber') to take measures to prevent such repeated disturbance. This can go beyond the claim to abstain from the activity that causes the disturbance and include the disturber being required to take positive action to prevent the imminent impairment by performing a so-called '*actus contrarius*',¹² a point that is discussed at a later stage in this analysis.¹³ Any right under section 1004 can exist only if there is no legal obligation for the claimant to tolerate the disturbance under either public or private law.¹⁴

⁸ L.S. Mullenix, *Public Nuisance: The New Mass Tort Frontier* (Cambridge University Press, 2023), pp. 8–25, at 9.

⁹ The terms 'GHG emissions' and 'emissions' are used interchangeably for legibility, unless it is pointed out that only CO₂ emissions are considered. GHG emission metrics are used to express emissions of different GHGs in a common unit. The IPCC uses aggregated GHG emissions and states these in CO₂-equivalents (CO₂-eq), using the Global Warming Potential with a time horizon of 100 years (GWP100). See IPCC, 'Summary for Policymakers', in IPCC (Core writing team, H. Lee & J. Romero (eds)), *Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (IPCC, 2023), pp. 3–39, at 4, 9, available at: <https://www.ipcc.ch/report/ar6/syr> (IPCC AR6).

¹⁰ RWE, 'Better Energy for a Better Future: Annual Report 2024', p. 44, available at: <https://www.rwe.com/-/media/RWE/documents/05-investor-relations/finanzkalender-und-veroeffentlichungen/2024-gj/2025-03-20-rwe-annual-report-2024.pdf>.

¹¹ V. Flatt & R.O. Zerbe, 'Climate Change Common Law Nuisance Suits: A Legal-Efficiency Analysis' (2019) 49(3) *Environmental Law*, pp. 683–702, at 686; *American Electric Power Company v. Connecticut*, United States (US) Supreme Court, 564 U.S. 410,424 (2011); 42 U.S.C. §§ 7401–7671q (2012).

¹² German Federal Court of Justice, 13 Jan. 2012, V ZR 136/11, para. 6; S. Herrler, 'Section 1004', in C. Grüneberg (ed.), *Bürgerliches Gesetzbuch: Commentary* (Beck, 84th edn, 2025), paras 12, 34; *Lliuya v. RWE*, n. 1 above, pp. 36–7.

¹³ See Section 2.2.

¹⁴ S. 1004(2) of the German Civil Code, n. 5 above, reads: 'The claim is excluded if the owner is obliged to tolerate the interference'. See *Lliuya v. RWE*, n. 1 above, pp. 39, 66.

This statutory rule has been further specified in the case law of the Federal Court of Justice.¹⁵ While the provision in question speaks of ‘further interferences’, an application for injunctive relief can also be filed where no interference with the property has occurred (yet), to address the risk of a ‘first’ interference.¹⁶ Thus, according to the case law, the property owner can seek to prevent a first impairment where there is a risk but no actual damage to the property.¹⁷ However, the claimant must prove that the risk of damage is *imminent*.

Building upon this body of law, the Court of Appeal in Hamm was asked to provide injunctive relief for an *imminent first impairment*. To succeed, the claimant had to prove that the GHG emissions of RWE, in particular CO₂, constituted not only an increased risk of a glacial lake outburst flood (GLOF) for the claimant’s property but reached the normative threshold of an imminent first impairment. The case law has established benchmarks to determine the required threshold for ‘imminence’, and the Court found that the risk of flooding – identified by Court-appointed experts, with a likelihood of around 1% over a 30-year period – was insufficient to meet the threshold.¹⁸

2.1. Proven or Not? Reasons that Inform the Conviction of the Judges

At first glance, it may be difficult to discern where the Court’s reasoning is based on the facts as argued and those that were sufficiently substantiated. According to the Code of Civil Procedure, it is the role of the Court to evaluate the evidence before it:

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.¹⁹

The Court based its reasoning on the assumption that already underlay the decision to begin the evidentiary stage of the proceedings in November 2017 – that the case was ‘conclusively argued’.²⁰ ‘Conclusively argued’ means that the facts as stated in the claimant’s submission, if proven, would justify the claim and bring the relief sought. If the asserted facts of the claim are disputed by the defendant, the Court may order that evidence be taken, and the claimant must substantiate the contested facts upon which the claim is based, while the defendant can provide evidence for the reasons for disputing the facts.²¹

¹⁵ German Federal Court of Justice, BGH, V ZR 230/03, p. 7.

¹⁶ This is considered general practice; see C.S. Rapatz, ‘Section 1004’, in F.J. Säcker et al. (eds), *Münchener Kommentar zum Bürgerlichen Gesetzbuch* (Beck, 10th edn, 2026), paras 75ff, 306ff.

¹⁷ *Lliuya v. RWE*, n. 1 above, pp. 35–6.

¹⁸ *Ibid.*, p. 127.

¹⁹ N. 2 above, s. 286.

²⁰ This is the so-called ‘Schlüssigkeitsprüfung’: *Lliuya v. RWE*, n. 1 above, Order for Hearing Evidence, 30 Nov. 2017, available at: <https://rwe.climatecase.org/en/legal#legaldocs>.

²¹ See Code of Civil Procedure, n. 2 above, ss. 358–9.

While the judgment confirmed that the claimant made a valid legal argument, the Court found that the claimant had not succeeded in proving that a first impairment was *imminent*.²² However, the Court reasoned that there were facts that constituted common knowledge where no further evidence was necessary.²³ Based on this common knowledge, the Court stated, for example, that it was the ‘conviction of the Senate’ (three judges are deciding) that ‘it had been foreseeable for the optimal observer in the role of an energy producer, since the mid-1960s, that anthropogenic GHG emissions would lead to global warming and the resulting harm’.²⁴ The Court also found that RWE’s GHG emissions made a traceable and material contribution to global GHG emissions,²⁵ just not one that resulted in an imminent threat of flooding in the concrete case.

2.2. Corporate Duties and State Obligations: Deep, Rapid, and Sustained Reductions in GHG Emissions

The case complements a growing field of litigation against corporations and between private actors that are transacting with each other in the shadow of legal concepts and regimes that have been altered or produced through climate law.²⁶ For example, in *Milieudefensie et al. v. Royal Dutch Shell Plc*, despite overturning the decision of the court of first instance,²⁷ the Dutch Court of Appeal confirmed that:

[companies] which contribute significantly to the climate problem and have it within their power to contribute to combating it, have an obligation to limit CO₂ emissions in order to

²² Civil Code, n. 5 above, s. 1004 reads: ‘(1) If the ownership is interfered with by means other than removal or retention of possession, the owner may demand that the disturber remove the interference. If there is the concern that further interferences will ensue, the owner may seek a prohibitory injunction. (2) The claim is excluded if the owner is obliged to tolerate the interference’.

²³ Under Code of Civil Procedure, n. 2 above, s. 291, facts that are common knowledge need not be substantiated by evidence.

²⁴ *Lliuya v. RWE*, n. 1 above, p. 49.

²⁵ *Ibid.* pp. 49–53, 59.

²⁶ It is estimated that globally around 20% of climate cases in 2024 targeted companies; see J. Setzer & C. Higham, ‘Global Trends in Climate Change Litigation: 2025 Snapshot’, Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science, June 2025, p. 5, available at: <https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2025/06/Global-Trends-in-Climate-Change-Litigation-2025-Snapshot.pdf>. See, e.g., *Native Village of Kivalina v. ExxonMobil Corp.*, 663 F.Supp.2d 863 (District Court of Northern District of California (US), 2009); *Bushfire Survivors for Climate Action Inc. v. Narrabri Coal Operations Pty Ltd* (New South Wales, Australia, 2022).

²⁷ *Milieudefensie v. Royal Dutch Shell*, District Court of the Hague (The Netherlands), 26 May 2021, ECLI:NL:RBDHA:2021:5337, English translation ECLI:NL:RBDHA:2021:5339 (*Milieudefensie DC*), paras 7.77, 7.95, 7.111. For analysis of the judgment see B. Mayer, ‘The Duty of Care of Fossil-Fuel Producers for Climate Change Mitigation: *Milieudefensie v. Royal Dutch Shell*, District Court of The Hague (The Netherlands)’ (2022) 11(2) *Transnational Environmental Law*, pp. 407–18; L. Burgers, ‘Response: An Apology Leading to Dystopia; Or, Why Fuelling Climate Change Is Tortious’ (2022) 11(2) *Transnational Environmental Law*, pp. 419–31; B. Mayer, ‘Judicial Interpretation of Tort Law in *Milieudefensie v. Shell*: A Rejoinder’ (2022) 11(2) *Transnational Environmental Law*, pp. 433–6.

counter dangerous climate change, even if this obligation is not explicitly laid down in (public law) regulations of the countries in which the company operates.²⁸

Milieudefensie appealed against the decision to the Supreme Court of the Netherlands in February 2025.²⁹ It is interesting to note that a new narrative emerges from the decision of the Dutch Court of Appeal, which also permeates the decision in *Lliuya v. RWE*. Even though the appellate court fell short of confirming the finding of the court of first instance that Shell was obliged to reduce its CO₂ emissions by net 45% at the end of 2030 relative to 2019,³⁰ the appeal ruling weaves in a social standard of care applicable to companies that is influenced by the horizontal effect of human rights and goes beyond public law rules ('even if this obligation is not explicitly laid down in (public law) regulations' – see quote above).³¹ The Court stated:

[drastically reducing emissions by 2030 would require] not only taking measures to reduce demand for fossil fuels, but also limiting the supply of fossil fuels. The social standard of care, interpreted on the basis of Articles 2 and 8 [of the European Convention on Human Rights (ECHR)]³² and soft law such as the [United Nations Guiding Principles on Business and Human Rights]³³ and [Organisation for Economic Co-operation and Development (OECD) Guidelines for Multinational Enterprises on Responsible Business Conduct]³⁴, requires producers of fossil fuels to take their responsibility in this respect.³⁵

Furthermore, the Court of Appeal reasoned that under the European Union (EU) Corporate Sustainability Due Diligence Directive (CSDDD) of 13 June 2024,³⁶ EU Member States are required to ensure that companies falling within the scope of the CSDDD, such as Shell:

²⁸ *Milieudefensie v. Royal Dutch Shell*, Court of Appeal, The Hague (The Netherlands) (CA), 12 Nov. 2024, ECLI:NL:GHDHA:2024:2099, English translation ECLI:NL:GHDHA:2024:2100 (*Milieudefensie* CA), para. 7.27.

²⁹ Milieudefensie, 'Explainer: Supreme Court Appeal in the *Milieudefensie v. Shell* Climate Case', 12 Feb. 2025, available at: <https://en.milieudefensie.nl/news/explainer-all-the-reasons-why-we-are-appealing-to-the-supreme-court>.

³⁰ *Milieudefensie* DC, n. 27 above, para. 4.4.55.

³¹ *Milieudefensie* CA, n. 28 above, paras 7.24–5; P. Minnerop, 'Integrating the "Duty of Care" under the European Convention on Human Rights and the Science and Law of Climate Change: The Decision of The Hague Court of Appeal in the Urgenda Case' (2019) 37(2) *Journal of Energy and Natural Resources Law*, pp. 149–79, at 160.

³² Rome (Italy), 4 Nov. 1950, in force 3 Sept. 1953, available at: <https://www.echr.coe.int/pages/home.aspx?p=basictexts>.

³³ Office of the High Commissioner for Human Rights (OHCHR), 'Guiding Principles on Business and Human Rights: Implementing the United Nations "Protect, Respect and Remedy" Framework', 16 June 2011, UN Doc. HR/PUB/11/04, available at: <https://digitallibrary.un.org/record/720245>.

³⁴ OECD, *Guidelines for Multinational Enterprises on Responsible Business Conduct*, first adopted 2011 and revised 2023 (OECD, 2023), available at: https://www.oecd-ilibrary.org/governance/oecd-guideline-s-for-multinational-enterprises_9789264115415-en.

³⁵ Ibid.

³⁶ Directive (EU) 2024/1760 on Corporate Sustainability Due Diligence and amending Directive (EU) 2019/1937 and Regulation (EU) 2023/2859, OJ L 2024/1760 (CSDDD).

adopt and put into effect a transition plan for climate change mitigation which aims to ensure, through best efforts, that the business model and strategy of the company are compatible with the transition to a sustainable economy and with the limiting of global warming to 1.5C in line with the Paris Agreement and the objective of achieving climate neutrality as established in Regulation (EU) 2021/1119, including its intermediate and 2050 climate neutrality targets, and where relevant, the exposure of the company to coal-, oil- and gas-related activities.³⁷

This climate transition plan must also set out time-bound targets in five-year increments from 2030 to 2050.³⁸ These new obligations, even if they leave some discretion, are nevertheless illustrative of the judicial acknowledgement of a responsibility to combat climate change that does not lie exclusively with states.³⁹

However, this shared responsibility is rooted in binding obligations of states under international law to regulate the activities of major emitters. The International Court of Justice (ICJ), in its advisory opinion on climate change of 23 July 2025,⁴⁰ seized the opportunity to confirm that states must adopt, both under the Paris Agreement⁴¹ and under customary international law, ‘regulatory mitigation mechanisms designed to achieve deep, rapid and sustained reductions of GHG emissions’.⁴² In particular, with respect to the mitigation obligation under the Paris Agreement, the ICJ specified that:

a party’s compliance with its obligations to pursue domestic mitigation measures under Article 4, paragraph 2, is to be assessed on the basis of whether the party exercised due diligence in its efforts and in deploying appropriate means to take domestic mitigation measures, including in relation to activities carried out by private actors.⁴³

Furthermore, the ICJ confirmed the observation of the International Tribunal for the Law of the Sea (ITLOS) that the ‘obligation of due diligence is particularly relevant in a situation in which the activities in question are mostly carried out by private persons or entities’.⁴⁴ Failure to ‘exercise due diligence by not taking the necessary regulatory and

³⁷ Ibid., Art. 22(1). The reporting and planning requirements for large undertakings with more than 1,000 employees will not change under the latest proposals: European Commission, ‘Proposal for a Directive amending Directives 2006/43/EC, 2013/34/EU, (EU) 2022/2464 and (EU) 2024/1760 as regards Certain Corporate Sustainability Reporting and Due Diligence Requirements, COM(2025) 81 final, 26 Feb. 2025. pp. 3–4.

³⁸ *Milieudefensie CA*, n. 28 above, para. 7.44. See also CSDDD, n. 36 above, Art. 22(1).

³⁹ *Milieudefensie CA*, n. 28 above, para. 7.26.

⁴⁰ International Court of Justice (ICJ), *Advisory Opinion on the Obligations of States in respect of Climate Change*, 23 July 2025, available at: <https://www.icj-cij.org/sites/default/files/case-related/187/187-20250723-adv-01-00-en.pdf> (ICJ, *AO Climate Change*).

⁴¹ Paris (France), 12 Dec. 2015, in force 4 Nov. 2016, available at: https://unfccc.int/sites/default/files/english_paris_agreement.pdf.

⁴² ICJ, *AO Climate Change*, n. 40 above, para. 282.

⁴³ Ibid., para. 252.

⁴⁴ Ibid., with reference to the International Tribunal for the Law of the Sea (ITLOS), *Request for an Advisory Opinion submitted by the Commission of Small Island States on Climate Change and International Law*, Advisory Opinion, 12 May 2024, *ITLOS Reports 2024*, p. 90, para. 236, available at: https://www.itlos.org/fileadmin/itlos/documents/cases/31/Advisory_Opinion/C31_Adv_Op_21.05.2024_orig.pdf (ITLOS, *AO Climate Change*). See also ICJ, *AO Climate Change*, n. 40 above, para. 252.

legislative measures to limit the quantity of emissions caused by private actors under its jurisdiction' may constitute an internationally wrongful act.⁴⁵

Read in this context of the regulatory due diligence obligations of states, the judgment of the Hamm Court provides further affirmation that climate targets can be achieved only if states and private actors heed the clear imperative of making deep, rapid, and sustained reductions in GHG emissions. Regulating the activities of large emitters must therefore be embedded in a national legal framework that enables states and private actors to transition away from fossil fuels.

3. The Court's Advancements of Private Nuisance Law

3.1. Facts and History of the Case

The legal dispute arose in respect of an alleged impairment of the property of Saúl Ananías Luciano Lliuya, a Peruvian farmer who lives in Huaraz (Peru). Huaraz is situated below the largest and most northern glaciated mountain region of the tropical Andes, the Cordillera Blanca. Underneath the glacier Palcaraju and the mountains Nevado Palcaraju and Nevado Pucaranra is the glacial lagoon Palcacocha. The front end of the lagoon (facing the glen) is held with a natural moraine dam, fortified by built structures.⁴⁶

Mr Lliuya claimed that the defendant company, the largest German energy provider RWE AG, had caused climate change impacts that affected the glacial lagoon Palcacocha through the company's release of large quantities of GHGs, in particular CO₂, arising especially from past and present coal-fired power generation. The danger for his property was a result of the reduced stability of the glacier and the increased water level in the lagoon located above the property.⁴⁷ A flood-triggering avalanche or a landslide were possible at any time.⁴⁸ A GLOF that could trigger a massive flood-wave, and take with it mud and debris, could be induced by a moraine-overtopping wave or through a breach of the dams.⁴⁹ Despite existing measures, the water level, as a result of increasing meltwater from the glacier, had again reached a dangerous level, making a GLOF very likely. A GLOF or a landslide could damage or destroy the claimant's property.

The defendant, RWE, argued that there was no legal basis for the liability of an individual emitter for the alleged consequences of global climate change. By contrast, it was the responsibility of the legislator to regulate cumulative, distant, and long-term damage through means other than litigation.⁵⁰ The defendant disputed that there was adequate causation because CO₂ emissions came from many sources and mix in the atmosphere. Natural processes in the atmosphere would lead to the unidentifiable mixing between GHGs, in addition to changes resulting from natural drivers, and the

⁴⁵ ICJ, *AO Climate Change*, n. 40 above, para. 428.

⁴⁶ *Lliuya v. RWE*, n. 1 above, pp. 3-4.

⁴⁷ *Ibid.*, p. 5.

⁴⁸ *Ibid.*

⁴⁹ *Ibid.*

⁵⁰ *Ibid.*, p. 8.

absorption of carbon through sinks.⁵¹ It was undisputed between the parties that the GHG emissions were not prohibited by law and had been regulated – and permitted – in accordance with the Greenhouse Gas Emissions Trading Act since 2011.⁵²

The argument concerning lack of causation had convinced the court of first instance. The Regional Court in Essen dismissed the claim in its judgment of 15 December 2016.⁵³ It held that whether an impairment of the claimant's property existed in the form of an acute flood risk could be left undecided as, in any case, there was no equivalent causation of the impairment. It found that the defendant's GHG emissions would not constitute a causal factor for the purported flood risk, as the contributions of all emitters were indistinguishably mixed in the atmosphere.⁵⁴ The Higher Court of Appeal disagreed with this view and, following the scientific evidence, acknowledged the causal quality of RWE's GHG emissions, as is explained in the following.

On appeal to the Higher Court of Appeal in Hamm, the claimant argued that RWE's CO₂ emissions were partially causal for the present danger to his property and that this form of contributory causation was sufficient to meet the threshold of section 1004(1) of the German Civil Code. Critically, without the defendant's contribution, the risk of flooding would be lower, and the *pro rata* share of the impairment was estimated to be proportional to RWE's share of emissions at 0.38% or, alternatively, should be determined by the Court.⁵⁵

RWE argued that the claim was inadmissible and unfounded. The company submitted that there was no immediate risk of a GLOF, and no individualised causal relationship could be established between its emissions and climate change or the alleged flood risk. There was no possibility to determine linear causality between its own emissions and climate change because of the incomprehensible number of emissions and the natural and chemical processes in the atmosphere.⁵⁶ Furthermore, the company disputed the alleged historic contribution of 0.47% to the global GHG emissions.⁵⁷ Fundamentally, RWE denied that climate models could prove causality in the legal sense.⁵⁸ RWE also stated that the claimant had settled below the lagoon with knowledge, or at least with negligent lack of knowledge, of an existing source of pollution and had built without planning permission, which meant he now had to tolerate the situation.⁵⁹

None of these arguments persuaded the Senate.

⁵¹ Ibid., p. 9.

⁵² Treibhausgas-Emissionshandelsgesetz (Greenhouse Gas Emissions Trading Act), 21 July 2011, BGBl. 2011, I, p. 1475.

⁵³ Landgericht Essen (Germany), Judgment of 15 Dec. 2016, Az 2 O 285/15.

⁵⁴ Ibid.

⁵⁵ *Lliuya v. RWE*, n. 1 above, pp. 12–5.

⁵⁶ Ibid., p. 9.

⁵⁷ Ibid.

⁵⁸ Ibid., pp. 9–10.

⁵⁹ Ibid., pp. 16–23.

3.2. The Substantive Legal Assessment of the Appeal

The Higher Court of Appeal found that the claim was admissible in so far as the claimant sought a declaratory judgment regarding the defendant's obligation to bear the costs *pro rata* for the asserted first imminent impairment of his property.⁶⁰

Jurisdiction

The Court stated that its international jurisdiction was founded on the EU Brussels I Recast Regulation on jurisdiction,⁶¹ and based also on the defendant's agreement to participate in the oral proceedings in the first instance, according to German civil procedure (section 39 of the Code of Civil Procedure).⁶² The claimant had the necessary legal interest in a declaratory judgment, the claim was sufficiently precise, and German law was applicable, meeting the requirements of the EU Rome II Regulation on applicable law.⁶³ Furthermore, both parties had also agreed in November 2017 that German law was applicable.⁶⁴

The fact that Mr Lliuya lived in Peru was thus no hindrance to bringing a claim under German civil law. The Court of Appeal referred to the jurisprudence of the Federal Court of Justice according to which the distance between the source of the disturbance and the affected property is irrelevant; proximity is not a prerequisite for a successful claim, both according to the wording and the meaning and purpose of the provision.⁶⁵ The application of section 1004 of the Civil Code was also not excluded based on the consideration that protective measures could be required either for the lagoon or for the property of the claimant.⁶⁶

Causation

The meaning of 'disturber' (the party interfering with the claimant's property) requires an actual or imminent impairment of the property through action or omission.⁶⁷ The question, therefore, was whether RWE had caused a disturbance by emitting large quantities of CO₂, a question that the Court answered positively. It is important to note the nuances here. The Court identified a causal relationship between RWE's emissions and the disturbance – that is, the impacts of climate change on the increase

⁶⁰ Ibid., p. 24.

⁶¹ Regulation (EU) No. 1215/2012 on Jurisdiction and the Recognition and Enforcement of Judgments in Civil and Commercial Matters [2012] OJ L 351/1, Arts 4(1) and 63(1).

⁶² *Lliuya v. RWE*, n. 1 above, p. 26. See also Herrler, n. 12 above, para. 5; Federal Civil Court of Justice (Germany), 3 Dec. 1992, IX ZR 229/91, para. 11. The relevant provision of s. 39 Civil Code of Procedure (n. 2 above) reads: 'Competence of a court as a result of a party having participated in court proceedings without objecting to the court's lack of jurisdiction (*rügelose Verhandlung*): Furthermore, the competence of a court of first instance is established by the fact that the defendant makes an appearance in oral argument on the merits of the case and fails to object to the court's lack of jurisdiction. This shall not apply where the notification stipulated by section 504 was not given'.

⁶³ Regulation (EC) No. 864/2007 on the Law Applicable to Non-Contractual Obligations (Rome II) [2007] OJ L 199/40, Art. 1(1).

⁶⁴ *Lliuya v. RWE*, n. 1 above, p. 33.

⁶⁵ Ibid., p. 39.

⁶⁶ Ibid., p. 36.

⁶⁷ Herrler, n. 12 above, paras 2–5.

of the risk for the claimant's property – but did not find that the normative threshold of a sufficiently imminent impairment had been reached.

In its elaboration to determine causation, the Court started by stressing that legal causality – and not causality as understood in the natural sciences – was relevant. This clarification dispelled the defendant's argument that challenged the suitability of climate models to evidence causation, as these models were not necessary to determine causation in the case at hand.⁶⁸ The Court then confirmed that the GHG emissions of RWE, including those of its subsidiaries, were causal in the legal sense, based on the following reasoning.

As a first step, legal causation requires the application of the equivalence theory and, in a second step, must be determined according to the theory of adequate causation. The theory of equivalence uses the '*conditio sine qua non*' test, which is similar to the 'but for' enquiry in common law.⁶⁹ Both tests require a counterfactual analysis to qualify a factor as a cause if it can be determined that the event would not have happened without the factor in question.⁷⁰ The theory of adequate causation is then used to eliminate unlikely factors from the causal chain.⁷¹ The test reduces the factors that are legally relevant to those that fall within the scope of foreseeability for the optimal observer. Accordingly, a factor is adequately causal only 'if it is capable of bringing about a result of the kind that has occurred, and not only under particularly peculiar, completely improbable circumstances that must be disregarded in the normal course of events'.⁷²

The Court first applied the *conditio sine qua non* test and confirmed that, based on the claimant's submission, the defendant was a direct disturber, and that there was a direct causal relationship between the CO₂ emissions, the increase in CO₂ concentrations in the atmosphere, and the increase in risk for the claimant's property.⁷³ In the second step, the theory of adequate causation was used,⁷⁴ taking into account all circumstances that would have been recognizable to an optimal observer at the time of the occurrence of the damaging event, or the act/omission causing the damage.⁷⁵ The Court clarified that in those cases where the point in time at which the damage occurs is significantly later than the damaging action or omission, the decisive point in time to determine foreseeability is the moment of the activity or omission in question.⁷⁶

⁶⁸ The defendant's claim is also not scientifically correct, as more lines of evidence are used to establish scientific causation, as discussed in Section 5.

⁶⁹ W. van Gerven, J. Lever & P. Larouche, *Tort Law* (Hart, 2000), p. 395; see also Minnerop & Otto, n. 7 above, pp. 56–60.

⁷⁰ Van Gerven, Lever & Larouche, n. 69 above; Minnerop & Otto, n. 7 above, pp. 56, 68; Minnerop, n. 7 above, p. 424.

⁷¹ Federal Court of Justice (Germany), BGH, I ZR 61/20 p. 7; BGH IX ZR 204/12, pp. 9–10.

⁷² Federal Court of Justice (Germany), 19 Oct. 2016, IV ZR 521/14, para. 15.

⁷³ For the *conditio sine qua non* formula see Federal Court of Justice (Germany), 14 Dec. 2016, VIII ZR 49/16, para. 17, with further references.

⁷⁴ *Lliuya v. RWE*, n. 1 above, pp. 48–9.

⁷⁵ *Ibid.*, p. 50.

⁷⁶ *Ibid.*, p. 48.

Based on generally known facts, for an optimal observer in the role of an energy producer, it was already foreseeable in the mid-1960s that anthropogenic GHG emissions would lead to global warming and the associated adverse consequences.⁷⁷

Citing the scientific measurements and evaluations of the climate researcher Charles D. Keeling, the Court found that evidence for the warming associated with a steadily increasing CO₂ concentration in the atmosphere was already available in 1958.⁷⁸ Keeling established that the increase in CO₂ expected from the burning of fossil fuels was measurable and significant, and would cause global warming with consequences such as the melting of the ice caps, a rise in sea level, and a warming of seawater.⁷⁹

In contrast to the view of RWE, and based on the available scientific knowledge and, in particular, the public debate of the scientific evidence, the company could have recognized that the CO₂ emissions generated as a ‘waste product’ of its coal-fired power generation were capable of contributing to the melting of glaciers as a result of the atmospheric greenhouse effect.⁸⁰ This would also be as a result of ordinary physical processes linked to the emissions and not a result of entirely unusual, unforeseeable circumstances that needed to be exempt from the causal chain. Considering this scientific knowledge would not have required the defendant to acquire special scientific expertise.⁸¹

Furthermore, neither the lack of specific knowledge nor the complexity of natural science processes exclude foreseeability. Especially energy-producing companies of the size of the defendant could be expected to follow the results of scientific congresses and specialist events as well as evaluate the international specialist literature.⁸² It is important to note that the Court at this point was convinced, based on the facts that it considered to be common knowledge, that a causal link between RWE’s GHG emissions and its contribution to climate change and the asserted increase in risk existed.⁸³ While the imminence of impairment could not be substantiated, the causal quality of RWE’s GHG emissions had been proven.

Significance of contributions to global emissions

The Court found the CO₂ emissions of RWE to be significant. It disagreed with the defendant’s view that the case was symptomatic of an ‘instrumentalization of the judiciary’⁸⁴ and that the case would lead to claims by ‘everyone against everyone’ or ‘all against all’, given that there was a difference in the size of causal contributions

⁷⁷ Ibid., p. 49.

⁷⁸ Ibid., pp. 49–50.

⁷⁹ R. Revelle, H.E. Landsberg & W.A. Nierenberg, ‘Restoring the Quality of Our Environment’, Report of the Environmental Pollution Panel, President’s Science Advisory Committee, Nov. 1965, available at: <https://nsarchive.gwu.edu/document/31937-document-2-white-house-report-restoring-quality-our-environment-report-environmental>; see also R. Licker et al., ‘Attributing Ocean Acidification to Major Carbon Producers’ (2019) 14 *Environmental Research Letters*, article 124060.

⁸⁰ *Lliuya v. RWE*, n. 1 above, p. 50.

⁸¹ Ibid.

⁸² Ibid., pp. 49–50.

⁸³ Ibid.

⁸⁴ Ibid., p. 63.

where some of these significantly increased the risk.⁸⁵ Noting that the defendant's argument in that respect was more of a political nature, the Court nevertheless explained that even if the defendant was one among many disturbers, this would not prevent the claimant from choosing to file a claim against RWE as a specific defendant making a measurable contribution to climate change.⁸⁶ In that respect, the Court explained that neither the defendant's large share of 0.38% of industrial CO₂ emissions nor its share of just under 0.24% of worldwide CO₂ emissions would appear negligible.⁸⁷ Moreover, in the list of the world's 81 largest CO₂ emitters, the defendant ranked 23rd.⁸⁸ The Court concluded, therefore, that RWE's share of industrial CO₂ emissions worldwide qualified as a significant contributing factor of global warming and its consequences.

Unlawful situation

The Court disagreed with the argument that to establish liability the claimant had to substantiate a breach of a duty, noting that this reading of the law (as suggested by RWE) would correspond neither to the wording nor to the purpose of section 1004 of the Civil Code. According to the Court, the term 'breach of duty' belonged to tort law (sections 823 and following of the Civil Code), which was systematically different from nuisance law, where a completely lawful activity can still lead to an unlawful situation that the property owner does not have to tolerate.⁸⁹ In short, the impairment of the property must be unlawful, but not the activity leading to it.

The defendant's argument that the claimant was under a legal obligation to tolerate the emissions because they were covered by German emissions regulations and, thus, not against the law, were therefore not accepted. Having a public law permit to emit under public law does not exempt a company from its obligations under civil law.⁹⁰ Furthermore, no duty to tolerate could be derived from the claimant's choice to live below the glacial lagoon. In that respect the Court pointed out that it had taken the opportunity to visit the area and take evidence by eyesight in Peru. On that basis, there was no reason for the Court to believe that the local authorities were unaware of the settlement, so that at the very least there was a form of tacit approval.⁹¹

4. The Challenges Posed by the Issue of Imminent First Impairment

Two critical numbers defined the Court's analysis of 'imminence'. Firstly, the period of 30 years; secondly, the factor that measured the probability of the potential impairment with 1%. In this section, we identify five points where the Court's legal

⁸⁵ Ibid.

⁸⁶ Ibid., p. 64.

⁸⁷ Ibid., pp. 52, 56.

⁸⁸ Citing the study by R. Heede, 'Tracing Anthropogenic Carbon Dioxide and Methane Emissions to Fossil Fuel and Cement Producers, 1854–2010' (2014) 122 *Climatic Change*, pp. 229–41 (according to the supplementary material of the study, RWE ranked 28th).

⁸⁹ *Lliuya v. RWE*, n. 1 above, p. 65.

⁹⁰ Ibid., p. 79.

⁹¹ Ibid., p. 83.

engagement with the scientific evidence is incomplete and could be strengthened by fully recognizing the scientific probabilities and levels of certainty.

4.1. The Normative Threshold of ‘Imminence’

According to the Court, the claimant, who incurred the burden of proof, failed in proving that a first imminent impairment of his property existed that would meet the threshold under section 1004 of the Civil Code. As mentioned earlier, to limit the scope of possible property interferences⁹² not any potential or abstract risk will qualify, only one that amounts to a concrete, immediately to be expected, imminent impairment.⁹³ The Civil Code is silent in terms of measuring the time span that suggests imminence. The Federal Court of Justice has established that a first impairment is imminent if there is a serious threat of a future, soon to be expected, or tangible event that makes a legal assessment possible.⁹⁴ Therefore, there are two intertwined factors that determine the legal assessment of imminence: (i) *proximity in time* and (ii) *seriousness of the threat*. The literature uses terminology such as ‘as soon as’, ‘in the foreseeable future’, ‘to be seriously and tangibly feared’.⁹⁵ In line with the case law, the Hamm Court of Appeal confirmed that the severity of the risk and the protected interests at stake had to be considered for the overall analysis of imminence.⁹⁶

Nevertheless, based on the evidence, the Court found that damage through flooding from the glacial lagoon Palcacocha and/or a mudslide – as a result of an increase in the volume of water in the lake, the release of an ice avalanche, a glacier collapse, a rock slide, or a combination of these circumstances – could not be expected with the probability required.⁹⁷ The Court-appointed experts specified that the risk of a large rockfall (Millionensturz) based on a 30-year observation period considered by the expert was around 0.5%, with a maximum probability of 4.7%, after applying a ‘climate factor’ to account for the changing risk of a GLOF-triggering avalanche as a result of climate change, as suggested by the claimant’s experts.⁹⁸

There was disagreement between the experts over the exact value of this climate factor.⁹⁹ For the Court, however, it was decisive that the experts also asserted that the concrete risk for the claimant’s property would be even lower, because of its location in relation to the lagoon.¹⁰⁰ In assessing the concrete risk, the Court also followed the views of its own experts, which disputed the evidence provided by the claimant’s expert concerning the changes in the distribution of permafrost and the resulting destabilization of the mountain side.¹⁰¹ According to the Court’s experts, there was no

⁹² See under Section 2.1.

⁹³ *Lliuya v. RWE*, n. 1 above, p. 92.

⁹⁴ Federal Court of Justice (Germany), 25 Feb. 1992, X ZR 41/90, para. 36.

⁹⁵ *Lliuya v. RWE*, n. 1 above, p. 92.

⁹⁶ *Ibid.*, p. 92.

⁹⁷ *Ibid.*, p. 95.

⁹⁸ *Ibid.*, pp. 122, 127.

⁹⁹ *Ibid.*

¹⁰⁰ *Ibid.*, pp. 122–3.

¹⁰¹ *Ibid.*, pp. 128–30.

relevant permafrost thawing below 5,000 metres, and no changes to the permafrost distribution had occurred during an earlier landslide in 2003 (which, according to the facts of the case, included significant changes through breaking of glacier ice, a flood wave, and increase in water volume in the lagoon).¹⁰² The Court was also convinced by its own experts that there was no possibility to seriously consider the developments of the lagoon beyond a time frame of 30 years.¹⁰³ Therefore, while the Court had found earlier that there was an increased risk, this was not sufficient to meet the normative threshold of imminence.

4.2. Methodological Choices that Determine Time Frame and Risk Factor

The following five points relate to determination of the time frame and the risk factor based on the Court's appointed expert evidence. These points not only merit further consideration, they also reveal why agreement on what constitutes 'best available science' must involve IPCC reports, as we explain in the following section.

Firstly, in accepting the analysis of the Court's appointed experts that 30 years define the relevant time span for a legal assessment, the Court cited reasons such as the impossibility to seriously estimate the developments affecting the lagoon, the unpredictability of changes that occurred in the past, and the contribution of factors such as the economic situation in Peru and the growth of the population in Huaraz.¹⁰⁴ While this may explain the Court's view to some extent, these reasons are not compelling for the determination of the cut-off date. Clearly distinguishing between qualitative and quantitative causality at this point may have prevented the Court from assigning a quantitative accuracy to the expected 1% risk of flooding over the next 30 years. The assumed certainty of a link between the increase in GHG emissions and the GLOF risk can be given only for the qualitative assessment – that is, the causal quality of RWE's CO₂ emissions for the change in the risk – but no equivalent quantitative certainty of the concrete contribution and the expected changes in the risk for the next 30 years can be established in a rapidly changing climate for a mountainous region with little observational data.¹⁰⁵ Therefore, the Court's legal assessment of the scientific data at this point should have considered the differences between the qualitative and the quantitative assessment of the causal link, and not doing this almost inevitably leads to an assumption of certainty for the risk factor and its continuity over time that is not supported by scientific evidence.

Secondly, and related to the point above, the judgment leaves open a question that sits uneasily with the Court's own rationale of using the best available scientific evidence. Even if one were to accept that the Court rightly concluded that a detailed legal and scientific assessment of the situation was possible for 30 years only, it would

¹⁰² Ibid., p. 129; for the facts of the 2003 event see p. 94.

¹⁰³ Ibid., p. 94.

¹⁰⁴ Ibid.

¹⁰⁵ A. Condom et al., 'Climatological and Hydrological Observations for the South American Andes: *In Situ* Stations, Satellite, and Reanalysis Data Sets' (2020) 8 *Frontiers in Earth Science*, article 92; P. Thornton et al., 'Coverage of *In Situ* Climatological Observations in the World's Mountains' (2022) 4 *Frontiers in Climate*, article 814181.

still be necessary to explain why there is an assumption that the risk factor remains *constant* during that time. By contrast, it is conceivable that there is decreasing scientific certainty as time passes. Considering the cumulative effects of climate change and current CO₂ emissions trends, the risk factor could increase, already in the near future, and well before the end of this decade. This would not necessarily entail a change in the RWE pro rata contributions but would affect the actual risk of significant damage and the ensuing evaluation of imminence, in particular, given the fact that changes in the cryosphere have a considerable lag in time; in other words, the impacts of RWE's emissions and all other past emissions will show up in the observational data in the decades to come.¹⁰⁶

Thirdly, the Court considered that even if, as argued by the claimant, a 'climate factor of 2-4' would be applied, the probability of an event that would threaten the claimant's property would still be less than 5%.¹⁰⁷ This increase in probability was evaluated as insufficient to assume an imminent impairment. The different numbers of percentages and factors that were discussed by the experts and the Court poignantly illustrate the challenges faced by the judiciary in navigating conflicting scientific evidence in legal reasoning.¹⁰⁸

Yet, the very fact that the Court faces such a difficult task in identifying a normative threshold for imminence calls for judicial caution. It reveals not only a significant legal challenge but also a fundamental disagreement between the experts in making and presenting their scientific assessments. This lack of scientific coherence affects the robustness and the resulting confidence levels of the evidence.¹⁰⁹ The reduced scientific certainty makes any legal appraisal not only more complicated, but it also increases the risk that a legal evaluation inevitably proceeds with a presumption of accuracy that does not exist.

This means that the legal argument and conclusion set aside the importance of confidence levels, a point that we discuss further below. In the present case, the disputed science nevertheless had a twofold effect: the uncertainties related to the numerical risk and how it may or may not change over time, but, importantly, they also affected the identification of the legally protected right – that is, the assumption that a risk existed only in respect of the claimant's property and not in respect of the right to health and the right to life. If these higher-ranking legally protected rights had

¹⁰⁶ B. Fox-Kemper et al., 'Ocean, Cryosphere and Sea Level Change', in V. Masson-Delmotte et al./IPCC (eds), *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press, 2021), pp. 1211–62, at 1214–7.

¹⁰⁷ *Lliuya v. RWE*, n. 1 above, p. 127.

¹⁰⁸ See, e.g., K. Sulyok, *Science and Judicial Reasoning: The Legitimacy of International Environmental Adjudication* (Cambridge University Press, 2020), p. 339.

¹⁰⁹ M.D. Mastrandrea et al., 'Guidance Note for Lead Authors of the IPCC Fifth Assessment Report on Consistent Treatment of Uncertainties', IPCC, Nov. 2010, available at: <https://www.ipcc.ch/site/assets/uploads/2018/05/uncertainty-guidance-note.pdf>; A. Kause et al., 'Communications about Uncertainty in Scientific Climate-related Findings: A Qualitative Systematic Review' (2021) 16(5) *Environmental Research Letters*, article 053005.

been found to be involved, established case law would have suggested that a 1% risk over 30 years would be sufficient for the threshold of imminence.¹¹⁰

Fourthly, the Court follows the methodology applied by its own experts,¹¹¹ while the methodology of the claimant's expert was not accepted.¹¹² It has already been pointed out that the Court is required to present persuasive and reasonable arguments as to why it follows the views of one particular expert.¹¹³ It is, of course, for the Court to assess the facts in the light of the evidence and there can be different evaluations of what constitutes a persuasive argument when accepting expert evidence. Indeed, the Court's choices in this regard have been criticized for 'downplaying the influence of climate change'.¹¹⁴ Yet, these critiques equally replace one *normative* evaluation of the influence of climate change with another.

Fifthly, the important point that underlies this critique is that courts face a particular challenge in applying the normative thresholds and criteria of the law to the scientific evidence, especially in situations where they are confronted with different and complex scientific methodologies and, on that basis, decide which expert evidence they follow. There is a fine line between judicial engagement with the scientific evidence and acknowledging different assessments, confidence levels, probabilities, and data gaps, thus respecting the rationality of scientific evidence and legal reasoning that applies the epistemological rules of law to science. To illustrate this point, the Court stated that scientists decided to apply a safety buffer 'to be on the safe side',¹¹⁵ and it then proceeded to correct these assumptions given that they favoured the claimant in 'multiple ways'.¹¹⁶ The Court thereby identified an overestimation of the risk based on certain assumptions about the height of the dam and the size and the direction of a potential flood wave. This then led the Court to conclude that the real risk was, by applying a 'realistic consideration', significantly lower, which would speak against the risk of an imminent impairment.¹¹⁷ In so doing, the Court resorted to a legal rationality that risks replacing epistemological rules of science.¹¹⁸ A similar risk emerges where the Court assigns priority to one specific scientific methodology over another, without explaining its choice based on the consideration of varying confidence levels.

4.3. The Baseline for 'Best Available Science'

The Court chose not to mention, let alone assess, the IPCC evidence on the effects of climate change on glaciers and permafrost, including the IPCC findings that are clearly

¹¹⁰ *Lliuya v. RWE*, n. 1 above, p. 113.

¹¹¹ *Ibid.*, p. 127.

¹¹² *Ibid.*, pp. 115–7, at 117 ('Even if the methodological approach of [the claimant's expert] would be applied and corrected by the above discussed points, no serious threat of a future, imminent interference with the claimant's property could be determined' (translation by the author)).

¹¹³ P. Grimm & J.-E. Schirmer, 'Success Without Victory: *Lliuya v. RWE* Decided', *Verfassungsblog*, 1 June 2025, available at: <https://verfassungsblog.de/liuya-rwe-climate-judgment>.

¹¹⁴ *Ibid.*

¹¹⁵ *Lliuya v. RWE*, n. 1 above, p. 130.

¹¹⁶ *Ibid.*, pp. 130–2.

¹¹⁷ *Ibid.*, p. 130.

¹¹⁸ *Ibid.*, p. 131.

formulated to apply to glaciers and permafrost regardless of their specific location.¹¹⁹ Some of the IPCC evidence has become common knowledge and must therefore be included in the legal assessment, according to section 291 of the Code of Civil Procedure.¹²⁰ As explained above, for facts that are common knowledge no further evidence must be provided.¹²¹

Yet, even if one were not to follow the view that IPCC reports have become common knowledge, the very existence of such reports is a unique characteristic of the field of climate science, which not only sets it apart from the use of other forms of scientific evidence in legal proceedings but also substantiates the concept of best available science. The IPCC was established by the World Meteorological Organization and the United Nations Environment Programme to ‘provide governments at all levels with scientific information that they can use to develop climate policies’.¹²² It currently has 195 member governments, and ‘thousands of experts from all over the world’ contribute to its reports.¹²³

The ICJ echoed the ‘view of participants’ that the reports ‘constitute the best available science on the causes, nature and consequences of climate change’, in its advisory opinion on state obligations in respect of climate change.¹²⁴ The IPCC assessment reports provide a regular update on the state of knowledge following expert assessments, and using IPCC reports in judicial proceedings differs fundamentally from presenting scientific evidence solely through the lens of a particular expert. Instead, the assessments are anchored in a comprehensive scientific review exercise, using expertise from all member countries and regions. In fact, it has been recognized that the ‘authors are required to reach agreement on their assessment of the state of the scientific research, specifying their level of confidence and clearly presenting any contradictory views, gaps in knowledge and uncertainties’.¹²⁵ Therefore, the IPCC’s high-confidence statements are well established and highly robust scientific evidence, representing a baseline for best available science. Newly published papers that are not yet assessed by the IPCC can shed further light on latest scientific developments and can also be relevant in legal assessments. However, deviating from IPCC high-confidence statements will require an equally robust scientific assessment to set aside IPCC baseline evidence in a court of law.

¹¹⁹ See, e.g., IPCC AR6, n. 9 above, pp. 25–115, at 69, 98.

¹²⁰ N. 2 above.

¹²¹ See Section 2.1.

¹²² IPCC, ‘About the IPCC’, available at: <https://www.ipcc.ch/about>.

¹²³ Ibid.

¹²⁴ IPCC, ‘Structure of the IPCC’, available at: <https://www.ipcc.ch/about/structure>; ICJ, AO *Climate Change*, n. 40 above, para. 74.

¹²⁵ Order of the First Senate of the German Federal Constitutional Court (Beschluss des Ersten Senats, Bundesverfassungsgericht), 24 Mar. 2021, 1 BvR 2656/18, para. 17, published 29 Apr. 2021 (*Neubauer v. Germany*). For a discussion of the case see P. Minnerop, ‘The “Advance Interference-Like Effect” of Climate Targets: Fundamental Rights, Intergenerational Equity and the German Federal Constitutional Court’ (2022) 34(1) *Journal of Environmental Law*, pp. 135–62; C. Möllers & N. Weinberg, ‘Die Klimaschutzentscheidung des Bundesverfassungsgerichts’ (2021) 76(22) *Juristen Zeitung*, pp. 1069–78, at 1072.

Given the procedures that determine the IPCC assessment cycles, the final reports provide the most authoritative scientific assessments on the causes, nature, and consequences of climate change, and have been used in national¹²⁶ and international courts to describe the scientific evidence and context of cases.¹²⁷ Using IPCC reports in courts provides the factual background for the legal reasoning. Any case-specific evidence that is not aligned with, or even contradicts, the findings of the IPCC reports, would require an additional, convincing scientific explanation. Absent any acknowledgement of the IPCC reports, let alone explaining why these reports fail to serve as a factual backdrop for the case-specific evidence in *Lliuya*, the Court's legal reasoning inevitably fails to acknowledge the best available science and the established scientific baseline that constitutes the point of departure for the case-specific risk assessment.¹²⁸

The melting of permafrost has been identified by the IPCC as a particularly high risk for humans and ecosystems in the near term, and any additional warming will further amplify permafrost thawing (high confidence).¹²⁹ The IPCC found that even if a 1.5°C temperature limitation is achieved, many low-elevation and small glaciers around the world will lose most of their mass or disappear within decades to centuries (high confidence).¹³⁰ Therefore, and even if the Palcaraju glacier is not a low-elevation glacier, the IPCC evidence that relates to glaciers in a warming world provides the relevant scientific information and also the context for any additional evidence. The expected glacial retreat has direct consequences for the expansion of glacial lakes.¹³¹

Moreover, a study specifically addressing the Palcaraju glacier, which builds on the IPCC baseline evidence, found that the greatest influence on the increase of a GLOF with regard to the role of the glacier are 'the steepness of the glacier snout, the growing lake area and the glacier's retreat'.¹³² It provided specific evidence that the 'retreat of the Palcaraju glacier, and the resultant expansion of Lake Palcacocha, have increased both the probability and potential magnitude of a GLOF', placing it in the highest hazard category.¹³³ This retreat of the Palcaraju glacier, according to this attribution study, is 'entirely the result of [anthropogenic] warming'.¹³⁴ Thus, while the concept of best available science can be vague in a non-climate science context, where courts must rely on various experts, this is not the case in climate science where IPCC reports provide an approved baseline that rests on robust assessments of the scientific literature. If a specific risk, impact or region is not covered, experts can provide more

¹²⁶ *Neubauer v. Germany*, n. 125 above, para. 16.

¹²⁷ *Verein KlimaSeniorinnen Schweiz and Others v. Switzerland*, European Court of Human Rights (ECtHR), Appl. No. 53600/20, Judgment, 9 Apr. 2024, paras 432, 510 (*KlimaSeniorinnen*); ITLOS, *AO Climate Change*, n. 44 above, paras 47–66; ICJ, *AO Climate Change*, n. 40 above, paras 75–87.

¹²⁸ *Lliuya v. RWE*, n. 1 above, p. 6.

¹²⁹ IPCC AR6, n. 9 above, pp. 25–115, at 69, 98.

¹³⁰ *Ibid.*, p. 71.

¹³¹ See e.g., H. Frey et al., 'Multi-Source Glacial Lake Outburst Flood Hazard Assessment and Mapping for Huaraz, Cordillera Blanca, Peru' (2018) 6 *Frontiers in Earth Science*, article 210, p. 2.

¹³² R. Stuart-Smith et al., 'Increased Outburst Flood Hazard from Lake Palcacocha due to Human-Induced Glacier Retreat' (2021) 14 *Nature Geoscience*, article 14, pp. 85–90, at 88.

¹³³ *Ibid.*

¹³⁴ *Ibid.*

case-specific evidence, but they must use the IPCC reports as a baseline to frame specific studies and to calculate risk factors.

4.4. The ‘Actus Contrarius’ Requirement

In cases where there is an imminent impairment, the disturber is under an obligation to ensure that the imminent impairment does not materialize.¹³⁵ This can go beyond the obligation to abstain from further contributions that could increase the risk; it demands an ‘*actus contrarius*’, a contravening or preventive action.¹³⁶ Ruling on the facts that there was no imminent impairment not only means that the causally relevant GHG emissions can continue, but it also absolved the Court from investigating or explaining the nature of the contravening action that could be conceivable, if the risk became imminent.

Would this require only protective measures, either for the lagoon or the claimant’s property, or could it entail the reduction of GHG emissions and even the removal of past GHG emissions? Considering the strong emphasis placed on the significance of RWE’s contributions, it cannot be excluded that an *actus contrarius* that actively prevents the property impairment could be required in the future – depending on the evidence provided. It would go beyond the scope of this article to explore the nature of the required measures in depth. Acknowledging this legal twist of nuisance law could either be perceived as a further litigation risk for large emitting companies, or indeed as an incentive to drive a just transition away from fossil fuels.

5. Best Available Science and Causality

The importance of distinguishing between qualitative and quantitative causation resonates from the legal analysis: while the causal quality of the GHG emissions of RWE for the increased risk of property damage was established (qualitative), the exact size of the contribution (that is, the factor by which the risk increased (quantitative)) was difficult to determine. Even scientific studies at times lack the necessary clarity required for this legal consideration. Scientific findings of the IPCC, including on causation and impact attribution, have been used in the academic literature specifically to support the development of the causal analysis at the intersection of science and law,¹³⁷ and national¹³⁸ and international courts have used IPCC science and the emerging structural arguments on climate causality.¹³⁹

¹³⁵ Herrler, n. 12 above, para. 33.

¹³⁶ Ibid.

¹³⁷ Marjanac & Patton, n. 7 above, p. 267; Minnerop & Otto, n. 7 above, pp. 56–7; W. Frank, ‘Klimahaftung und Kausalität’ (2013) 24(1) *Zeitschrift für Umweltrecht*, pp. 28–31; T. Pfrommer et al., ‘Establishing Causation in Climate Litigation: Admissibility and Reliability’ (2019) 152 *Climatic Change*, pp. 67–84, at 68.

¹³⁸ R (on the application of Finch on behalf of the Weald Action Group) v. Surrey County Council and Others [2024] UKSC 20, paras 67–71; Friends of the Earth Ltd and South Lakeland Action on Climate Change v. Secretary of State for Levelling Up [2024] EWHC 2349 (Admin), paras 101–2.

¹³⁹ ICJ, AO *Climate Change*, n. 40 above, paras 425–32; KlimaSeniorinnen, n. 127 above, paras 424–40; Minnerop, n. 7 above, p. 424.

An important legal finding that emerges from *Lliuya* is that the Court was convinced that RWE's emissions were a cause of climate change and that a causal link between RWE's GHG emissions and the asserted increase in a GLOF risk existed. At the same time, the Court used scientific studies from around 60 years ago instead of IPCC science to establish causation. It was also not in a position – after hearing the expert evidence – to acknowledge and articulate in its reasoning the quantitative uncertainties that surround the assumed risk factor of 1% and its anticipated stability over 30 years.

The discussion of causation in science and law in this section firstly demonstrates how the law must rely on best available scientific evidence to establish a causal link and to attribute changes in risks. It then addresses the limitations of making causal inferences from past scenarios – and even from the present – to inform future risks in a rapidly changing climate.

5.1. Establishing Causality in Climate Science: Multiple Lines of Evidence

Causality in science, including in climate science, is established by using different independent lines of evidence. All of these various lines of evidence provide an answer to the question of whether a factor qualifies as a cause. As every method and data set has limitations, using different lines of evidence is the main method to establish higher levels of scientific certainty in causal inquiries.¹⁴⁰ Every study that adheres to the epistemological rules of scientific investigation includes an assessment of the level of confidence or certainty in the obtained results, but only taken together, in the context of multiple studies, can high confidence levels and, as such, scientific facts be established.¹⁴¹

There is experimental evidence for the warming caused by GHGs that provides the earliest measurable evidence, even before observations started or climate models existed.¹⁴² In addition, there is a strong physical foundation that also informed these first experiments, that even before warming was detectable, it was already foreseeable from the combustion of fossil fuels.¹⁴³ Indeed, industry documents confirm this awareness long before major impacts became visible.¹⁴⁴ Different lines of evidence support this finding and, in contrast to RWE's argument, these lines of evidence, used

¹⁴⁰ C. Mears et al., 'Assessing Uncertainty in Estimates of Atmospheric Temperature Changes from MSU and AMSU Using a Monte-Carlo Technique' (2011) 116 *Journal of Geophysical Research: Atmospheres*, article D08112; B.D. Santer et al., 'Exceptional Stratospheric Contribution to Human Fingerprints on Atmospheric Temperature' (2023) 120(20) *Proceedings of the National Academy of Sciences*, article e2300758120, p. 10; M.G. Donat et al., 'Temperature and Precipitation Extremes in Century-long Gridded Observations, Reanalyses, and Atmospheric Model Simulations' (2016) 121(19) *Journal of Geophysical Research: Atmospheres*, pp. 11174–89.

¹⁴¹ P.N. Edwards, 'History of Climate Modelling' (2010) 2(1) *WIREs Climate Change*, pp. 128–39, at 129.

¹⁴² J.D. Ortiz & J. Roland, 'Understanding Eunice Foote's 1856 Experiments: Heat Absorption by Atmospheric Gases' (2020) 76(1) *Notes and Records*, pp. 67–84 at 74–9.

¹⁴³ *Ibid.*, p. 78.

¹⁴⁴ B. Franta, 'Early Oil Industry Disinformation on Global Warming' (2021) 30(4) *Environmental Politics*, pp. 663–68, at 665.

to build causal chains in the climate context, are not based on climate models, but climate models only form one, often the least important line, of evidence. By contrast, in addition to the fundamental laws of physics (conservation of energy, mass, and momentum) that govern the climate system, and the experimental evidence mentioned above, the most important and constantly improved line of evidence for the causal relationship between GHG emissions and global warming is based on weather observations, including those upon which the calculation of global mean temperature is based.¹⁴⁵ These observations are analyzed using regression-based statistical methods, also called ‘fingerprinting’ methods, firstly to detect and then to attribute climate change to various external factors.¹⁴⁶ These methods use both, observations that provide empirical evidence and climate model simulations that provide a combination of theoretical and statistical evidence.¹⁴⁷ For global mean temperature rise, many different statistical approaches have been used, and they independently confirm that it is impossible to explain the observed warming without including the additional GHG from burning fossil fuels in the statistical models.¹⁴⁸ Variations of linear regression models address structural model uncertainty and uncertainty arising from internal variability and the influence of chaotic changes in day-to-day weather and other phenomena, such as the El Niño Southern Oscillation, that are inherent in the climate system.¹⁴⁹

No climate model needs to be employed to explain the strong causal relationship between the burning of fossil fuels and global warming. However, climate models do provide an additional line of evidence, as they are specific mathematical representations of physical laws.¹⁵⁰ Simple models simulate the planetary energy balance based on the conservation laws of energy and mass, while complex models include the fundamental physical principle of the conservation of momentum and simulate weather directly.¹⁵¹ These physics-based models, independent of observations, reproduce the observed warming when using real GHG data. However, because of computational limits, models simplify aspects of the climate system, introducing uncertainties, rendering quantitative assessments – that is, measuring the exact

¹⁴⁵ V. Eyring et al., ‘Human Influence on the Climate System’, in Masson-Delmotte et al./IPCC (eds), n. 106 above, pp. 423–552, at 426–7; K. Marvel et al., ‘Twentieth-Century Hydroclimate Changes Consistent with Human Influence’ (2019) 569 *Nature*, pp. 59–65; E. Fischer & R. Knutti, ‘Anthropogenic Contribution to Global Occurrence of Heavy-Precipitation and High-Temperature Extremes’ (2015) 5 *Nature Climate Change*, pp. 560–4.

¹⁴⁶ Eyring et al., n. 145 above, p. 430, para. 3.3.1.

¹⁴⁷ See, e.g., F.E.L. Otto, ‘Attribution of Extreme Events to Climate Change’ (2023) 48 *Annual Review of Environment and Resources*, pp. 813–28, at 818; E. Fischer & R. Knutti, ‘Observed Heavy Precipitation Increase Confirms Theory and Early Models’ (2016) 6 *Nature Climate Change*, pp. 986–91.

¹⁴⁸ Eyring et al., n. 145 above, pp. 426–7.

¹⁴⁹ Regression-based models, also called ‘optimal fingerprinting’, are statistical methods to disentangle and identify the importance of different drivers of a statistically modelled process. They were first applied, in 1997, by Hasselman to global mean temperature, for which he was awarded the Nobel Prize for physics in 2021: K. Hasselmann, ‘Multi-Pattern Fingerprint Method for Detection and Attribution of Climate Change’ (1997) 13(9) *Climate Dynamics*, pp. 601–11.

¹⁵⁰ P.N. Edwards, *A Vast Machine: Computer Models, Climate Data, and the Politics of Global Warming* (The MIT Press, 2010), pp. 350–89.

¹⁵¹ Edwards, n. 141 above, p. 129.

contribution of global warming to a concrete event – on local scales more difficult to accomplish than qualitative assessments and those that relate to a global scale.¹⁵²

A similar physical foundation as for global warming in general exists with regard to the influence of climate change on permafrost in the Peruvian Andes. Even if – as stated by the Court's experts and followed by the judges – no significant changes in the distribution of permafrost have been observed in the past for the mountain region surrounding the lake Palcacocha, it would be erroneous to conclude on that basis that there will be no or even a reduced likelihood of melting in the future. In fact, the best available science (see Section 4.3) of the IPCC implicates that melting of permafrost has already been attributed to continued and increasing global warming, and that future warming scenarios must be taken into account when considering the trajectory of permafrost thawing, including at the local level.¹⁵³ Assuming a low risk, or describing the risk as abstract-theoretical in the absence of certainty as to the future distribution of local permafrost and the potential danger of large rock falls, limits the ability of the law to trace evidentiary uncertainties comprehensively.

The absence of scientific evidence for a specific type of climate change harm does not entail that the already well-established causal evidence (that indicates a certain trend and demonstrates that the respective consequences will materialize) can be ignored in the risk assessment. This would set aside the best available science that integrates multiple lines of evidence, including the physical laws that underlie the reaction of frost and ice to rising temperatures. Concluding that the risk of harm is low, and will not change over a period of 30 years during which further warming will occur, fails to appraise established IPCC science *and* the underpinning physical laws.

Presenting scientific studies in any legal setting can be a form of best available science only if the evidence clearly distinguishes between physical laws and the case-specific data sets, using the IPCC assessments as the baseline. Deviations from the baseline of best available science (i.e., case-specific causal claims about a climate-related impact that are not fully aligned with or even contradict the established baseline) must be very carefully evaluated in law. It means that a specific case will be assessed against a causal field of evidence on the impacts of climate change on permafrost. This causal field that describes the impact of global warming on permafrost deserves more legal attention. Even in the absence of case-specific data, the observation of permafrost changes over the last 10,000 years, as mentioned by the Court, cannot be used to predict future permafrost distribution. Because of the delayed response of the cryosphere to warming, the implications of the warming will be measurable only in the coming decades. The case-specific evidence would need to establish why permafrost in this specific situation would react differently.

¹⁵² Ibid. p. 131.

¹⁵³ R. Hock et al., 'High Mountain Areas', in H.-O. Pörtner et al./IPCC (eds), *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate* (Cambridge University Press, 2019), pp. 131–202; C. Taylor et al., 'Glacial Lake Outburst Floods Threaten Millions Globally' (2023) 14 *Nature Communications*, article 487, p. 2.

5.2. Qualitative and Quantitative Causality

So far, it has not been clearly articulated in the legal literature that the law should, as does the science, distinguish between a qualitative and a quantitative finding of causality, in the context of different trajectories of future warming. The well-established evidence that causally links increasing global warming to heightened flood risks in high mountainous regions constitutes a *qualitative* statement that can be made with high confidence.¹⁵⁴ By contrast, a *quantitative* statement would be the determination of the size of the contribution of a specific level of warming to the general or even an individual flood risk – that is, the role of sustenance that can be ascribed to a factor in a set of conditions that may influence the event in combination with other concurrent causes.¹⁵⁵ This requires additional scientific evidence. The confidence in the evidence of a causal link in most cases will depend on whether the aim is to establish *qualitatively* whether there is a causal link or whether the size of the contribution needs to be *quantitatively* determined.¹⁵⁶ Generally, certainty is higher in qualitative statements and in cases where physical laws underpin the evidence.¹⁵⁷

To determine the flood risk in a specific location requires scientists to establish evidence by estimating which drivers are important, followed by a qualitative assessment of changes in those drivers.¹⁵⁸ On that basis, a quantitative assessment can be undertaken. This could entail, for example, analyzing mean changes in temperatures across smaller regions (for instance, countries such as Peru) and climatic regions such as the Andes, in the wider context of examining changes in permafrost and glaciers globally. The starting point for the qualitative and the quantitative assessments would be the IPCC *Special Report on the Ocean and Cryosphere in a Changing Climate*, which found that permafrost temperatures have increased globally (very high confidence) and that glaciers worldwide have lost mass (very high confidence).¹⁵⁹ The Report states:

In many high mountain areas, glacier retreat and permafrost thaw are projected to further decrease the stability of slopes, and the number and area of glacier lakes will continue to increase (*high confidence*). Floods due to glacier lake outburst or rain-on-snow, landslides and snow avalanches, are projected to occur also in new locations or different seasons (*high confidence*).¹⁶⁰

These assessments are not only based on models but they also rely on physical laws for both the qualification and the quantification of the causal links, such as that when

¹⁵⁴ Hock et al., n. 153 above, pp. 158–9, para. 2.3.2.

¹⁵⁵ Minnerop & Otto, n. 7 above, p. 56.

¹⁵⁶ Hock et al., n. 153 above, pp. 158–9, Fig. 2.7.

¹⁵⁷ See, e.g., D. Chen et al., ‘Framing, Context, and Methods’, in Masson-Delmotte et al./IPCC, n. 106 above, pp. 147–286.

¹⁵⁸ Hock et al., n. 153 above, pp. 158–9, Fig. 2.7.

¹⁵⁹ IPCC, ‘Summary for Policymakers’, in Pörtner et al./IPCC, n. 153 above, pp. 3–35, at 18.

¹⁶⁰ Ibid. p. 17, para. B.1.5 (emphasis in original).

temperatures increase globally, the likelihood also increases that local temperatures reach levels where ice and snow melting begins.¹⁶¹ These physical laws are the starting point for any quantification of the risk, and they must equally be considered in assessing the changes in risks and the determination of normative thresholds such as imminence. There would indeed need to be an additional source of cooling to reverse the physical laws that underpin the causal quality of GHG emissions for glacier and permafrost melting.

Without further assessments, the scientifically valid conclusion in *Lliuya* would be that the risk can be quantified only within very large margins of uncertainty. Assuming a stable risk factor in the legal reading of the science disregards the physical laws and risks ignoring the best available science. While the legal assessment of confidence levels will depend on the science presented in any concrete case, a low confidence level resulting from expert evidence that differs from the baseline of IPCC reports and the physical laws that underpin climate change will always require very cautious legal treatment.

Moreover, the normative evaluation of the role of permafrost and the Court's assessment of past changes to determine the relevant time frame for the GLOF risk assessment point to an underlying assumption that the past can be a reliable guide for the future development in any case. However, available observations show that even in the past, the risk factor was not stable and the flood risk has increased further as a result of the increase in the size and water volume of the glacial lake, caused by the melting of the glacier.¹⁶² It is certain that the melting will continue, as a result of the lagged effect of glacier melt with regard to global mean temperature increase, the expected direct effects on the thawing of permafrost, summer heatwaves destabilising slopes and increasing the risk of rockslides, in combination with other drivers of flood risk from glacier lakes as discussed by the IPCC.¹⁶³ All of these factors are also changing rapidly, and an assessment of how these rapid changes in the short, mid, and long term influence the flood risk within the next 30 years would have required an assessment of changes *in these factors*. It is not possible to arrive at a conclusion for the quantification of risk without an evaluation of studies that pertain to changes in these drivers.¹⁶⁴

6. Conclusions

The pioneering judgment of the Hamm Court of Appeal has concluded a long lawsuit and clarified the applicable standards under section 1004 of the German Civil Code in the context of climate change. The proceedings have prompted significant scientific,¹⁶⁵

¹⁶¹ Ibid., p. 19.

¹⁶² Stuart-Smith et al., n. 132 above, p. 88.

¹⁶³ Hock et al., n. 153 above, pp. 158–9.

¹⁶⁴ Ibid., p. 160, illustration.

¹⁶⁵ Stuart-Smith et al., n. 132 above; C. Huggel et al., 'Anthropogenic Climate Change and Glacier Lake Outburst Flood Risk: Local and Global Drivers and Responsibilities for the Case of Lake Palcacocha, Peru' (2020) 20(8) *Natural Hazards and Earth System Sciences*, pp. 2175–93; L. Harrington & F.E.L. Otto, 'Attributable Damage Liability in a Non-Linear Climate' (2019) 153 *Climatic Change*, pp. 15–20.

legal,¹⁶⁶ and interdisciplinary research along the way,¹⁶⁷ and the judgment paves the way for further research. It provides valuable insights into the role of private nuisance law in defining corporate obligations in respect of climate change and demonstrates how causation and normative thresholds, such as the significance of contributions and imminence of first impairment, can be applied under section 1004 of the Civil Code.

As the analysis has revealed, the judges faced significant challenges in navigating the scientific evidence and experts' views. The decision reaffirms the imperative to identify, present, and evaluate the best available science in legal assessments. In climate litigation, the physical laws of climate change and the IPCC assessment reports form a baseline of best available science, and high-confidence statements can be treated as scientific facts in the courtroom. Scientific certainties, margins of uncertainties, and variations in confidence levels must be clearly articulated in science and assessed accordingly in law. Using the existing best available science as a starting point, the research community is tasked to pursue research that can generate additional case-specific scientific evidence.

An improved legal reading of scientific evidence can emerge from that co-production and improve the likelihood of resolving disputes in a court of law. Most importantly, it will forge the knowledge to pre-emptively design legal frameworks cognizant of both the human contribution to extreme weather events and slow onset events, and the responsibility to act upon that knowledge to avoid harm. A clearer delineation between qualitative and quantitative evidence in the causal reasoning, the appreciation of confidence levels and probabilities, a better understanding of normative and scientific thresholds and the role of physical laws, and improving the reliability of scientific evidence all contribute to this aim.

It should be noted that other courts in Germany will not be bound by the decision of the Court of Appeal. They will certainly be well advised to consider the judicial reasoning and the standards that emerge, but there is no rule of binding precedent. Writing about the emerging accountability of carbon majors, Heede suggested that, in science, progress is built on the work of others.¹⁶⁸ The same is true for law and legal reasoning. The evolution of legal concepts in the context of climate change requires interdisciplinary research to address climate change and its devastating impacts that are felt and feared especially by vulnerable communities.

¹⁶⁶ Marjanac & Patton, n. 7 above, p. 267.

¹⁶⁷ See, e.g., Minnerop & Otto, n. 7 above; F.E.L. Otto et al., 'Causality and the Fate of Climate Litigation: The Role of the Social Superstructure Narrative' (2022) 13(5) *Global Policy*, pp. 736–50.

¹⁶⁸ R. Heede, 'The Arc of the Carbon Majors Work Bends Toward Fossil Fuel Company Accountability', Climate Accountability Institute, 29 Mar. 2024, available at: <https://climateaccountability.org/wp-content/uploads/2024/03/Heede-CarbonMajorsEssay-Apr24.pdf>.

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