

# Equalising the evidence base for adaptation and loss and damages

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## Abstract

Since the UNFCCC Paris Agreement came into force after 2015 international climate policy rests on three pillars: mitigation, adaptation and loss and damage. However, while there are clear agreed-upon metrics to measure emissions, base mitigation goals against and hold countries and companies accountable to, the evidence base for the impacts of climate change to inform adaptation and loss and damage is very different. There are no agreed-upon metrics, nor are there guidelines or criteria to delineate the impacts of climate change from other drivers of losses and damages. This imbalance is reflected in the lack of ability to set and enforce goals. With a new body of scientific evidence introduced in the IPCC, we argue that this can change. Especially with an increasing number of climate litigation cases being recognised as a legitimate root to justice, and thus being given due consideration in courts, the imbalance in evidence could change and put adaptation and loss and damage on more equal footing with mitigation.

## 1 | LITTLE PROGRESS ON ADDRESSING ADAPTION AND LOSS AND DAMAGES

For decades, many countries in the world were not only aware but experienced first-hand that losses and damages from extreme weather events are extremely costly, and set developmental gains back, sometimes severely, by, for example increasing poverty, inequity and inequality in human health (Nagy et al., 2018). Similarly, the fact that human-induced climate change manifests to a large degree through changing risks of extreme weather events has long been known. Already the very first Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) noted that ‘changes in the variability of weather and the frequency of extremes will generally have more impact than changes in the mean climate at a particular location’ (IPCC, 1992). However, while this knowledge is evidenced in principle on a global scale, there is no comprehensive assessment of the impacts of human-induced climate change.

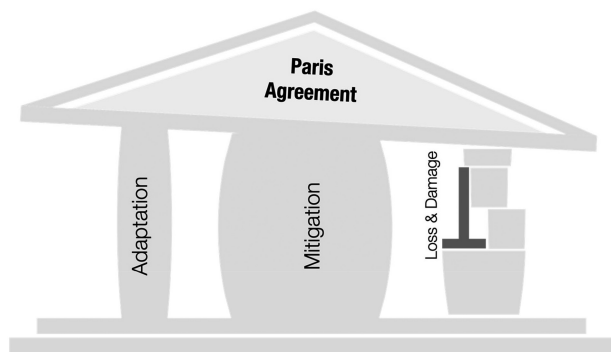
After more than two decades of international negotiations on climate change, the 2015 Paris Agreement is the key basis for international climate policy. It commits states, high and low income alike, to contributing to global goals on mitigation of, and adaptation to, the impacts of climate change (UNFCCC (United Nations Framework Convention on Climate Change), 2015). The Agreement also set a thus-far unmet floor of USD 100 bn in annual finance to support mitigation and adaptation measures in developing states.

Since the Paris Climate Agreement was established, international climate policy thus rests on three pillars: loss and damage (Article 8), adaptation (Article 7) and mitigation (Articles 4–6).

While these three pillars indeed describe the different dimensions of addressing the physical threats from human-caused climate change, an architectural structure would never stand if three pillars were required for support (Figure 1). Instead, most of the house illustrating evidence and progress in contemporary international climate policy consists of the mitigation pillar, with adaptation maybe supporting a non-load-bearing

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**FIGURE 1** Schematic of the uneven evidence base for the three pillars of the Paris Climate Agreement.

little roof whereas the loss and damage pillar is currently largely ornamental. This is not necessarily obvious when looking at the Paris Agreement itself but becomes obvious when looking at progress in implementing the Paris Agreement since 2015 and in particular the evidence base and measures available to facilitate this implementation.

We hypothesise that progress with respect to adaptation and in particular loss and damage is slow, partly due to the lack of evidence and metrics and thus knowledge and awareness of the impacts of human-induced climate change.

The main measure to assess progress in implementation established in the Paris Agreement is the Global Stocktake (Article 14, Paris Agreement) where parties are to periodically take stock of the progress being made with respect to the long-term goals set out in the Paris Agreement. 'It shall do so in a comprehensive and facilitative manner, considering mitigation, adaptation and the means of implementation and support, and in the light of equity and the best available science'. (ibid. Article 14.1). The first global stocktake is scheduled for 2023, with subsequent reviews to take place every 5 years.

For mitigation, while not straightforward, metrics to measure greenhouse gas emissions as well as short-lived climate forcers have been developed as part of the IPCC task force on greenhouse gas inventories (Calvo Buendia et al., 2019) based on a comparably large basis of literature that is continually added to (see e.g. Allen et al., 2022). These metrics allow for progress in mitigation already achieved to be measured and pledges set out in Nationally Determined Contributions (NDCs) to be tracked. Furthermore, it likely contributed to the fact that most of present-day climate finance flows towards mitigation while adaptation funding only represents a small proportion of global climate finance (IPCC SYR LR, 2023, p. 62).

The situation is very different when it comes to adaptation and Loss and Damage. The Paris Agreement aims to strengthen the ability to adapt to the adverse impacts of climate change globally and in Article 7 sets

### Policy Implications

- No criteria currently exist to measure loss and damage and formulate concrete adaptation goals, hindering climate justice on an international scale.
- The establishment of the loss and damage fund requires urgent steps towards defining criteria for assessing evidence and eligibility. It is important that this happens in a way that available evidence is used, but global inequality is not further deepened.
- There is a need for an IPCC task force on climate impact metrics (similar to the Task Force on National Greenhouse Gas Inventories (TFI) to close this evidence gap by developing a framework and metrics for a systematic assessment of climate impacts around the planet.
- Climate litigation can play a crucial role in setting and enforcing comprehensive criteria to assess evidence for loss and damage and adaptation needs. It needs a wide recognition of the opportunities and risks in using the current evidence base in order to avoid creating tools that do not help those most vulnerable to the impacts of climate change.

forth the global goal on adaptation. This goal has the objective to enhance adaptive capacity and resilience and to reduce vulnerability, with a view to contributing to sustainable development (UNFCCC, 1992). In Article 8 of the Paris Agreement parties agreed to enhance understanding, action and support to with respect to losses and damages occurring due to the adverse effects of climate change. Under UNFCCC, in contrast to IPCC, climate change without further qualification denotes anthropogenic climate change.

However, despite the undeniable importance of adaptation to address human-induced climate change, not least highlighted by the existence of a whole IPCC working group on 'Impacts, Adaptation and Vulnerability' (IPCC Working Group II), there is no metric to measure successful adaptation (Dilling et al., 2019). In addition, in most countries that have set national adaptation policies, no large-scale assessments exist of how people are actually adapting (Tompkins et al., 2018). This also means that while there is a global goal on adaptation, it is vague and therefore enforcement is rendered difficult.

Loss and Damage has been part of the UNFCCC negotiations since the early 1990s when developing countries highlighted the need to address in particular losses and disruption from sea level rise. Loss

and Damage was formally included in the negotiations with the Bali Action Plan (Decision 1/CP.13) in 2007 and more systematically in 2013, when the ‘Warsaw International Mechanism for Loss and Damage associated with Climate Change Impacts (Loss and Damage Mechanism)’ was established at COP19 (November 2013) in Warsaw, Poland ‘to address loss and damage associated with impacts of climate change, including extreme events and slow onset events, in developing countries that are particularly vulnerable to the adverse effects of climate change’. The mechanism aims to strengthen understanding and dialogue but also uses wording similar to Article 8 in the Paris Agreement on enhancing action and support. While some dialogue certainly happened, including the Santiago network, which has been introduced at COP25 in 2019 to bring technical assistance (mainly in the form of knowledge by linking with non-state actors) to vulnerable countries, there is still no definition of what constitutes Loss and Damage and interpretations between constituents of the Paris agreement divert considerably (Boyd et al., 2017). Consequently, there are no agreed-upon metrics to identify Loss and Damage, neither from slow-onset nor extreme weather events.

The discrepancy in evidence and thus accountability for adaptation and Loss and Damage in contrast to mitigation can be seen most clearly outside the climate negotiations, in the courtrooms.

For climate mitigation, recent court rulings have held national governments responsible for having too weak national mitigation goals, inconsistent with the Paris Agreement. Examples are Germany in *Neubauer et al. versus Germany*, Belgium and the Netherlands, but also Brazil in *PSB et al., versus Brazil* where the government was forced to reintroduce more stringent deforestation policies. These court rulings were also possible because clear, globally accepted, metrics existed against which existing policies could be assessed.

For adaptation, while individual cases attempted to force governments to more stringent adaptation or support of their citizens to cope with loss and damage, no court rulings exist. However, this will likely change in the next years and months as evidence for individual losses is available now and is used as evidence in the courts. This change in how loss and damage and adaptation cases are faring in courts now, and the fact that evidence is available, corroborates our hypothesis that the lack of evidence impeded progress in adaptation and Loss and Damage. But also suggests that addressing the lack of evidence could indeed lead to progress in implementing Loss and Damage and adaptation.

In the following section, we discuss current dynamics in climate litigation. This is followed by a section on the current evidence base on climate change impacts, followed by a section detailing how it could be improved to put adaptation and loss and damage on slightly more

equal footing to mitigation using the just established Loss and Damage Fund as an example. We conclude by discussing how this in the context of the court developments could precede the IPCC and UNFCCC in defining metrics to measure climate change impacts and thus subsequently improve fairness in climate policy.

## 2 | LOSS AND DAMAGE IN THE COURTS

The last few years have shown that courts can play a transformative role in advancing climate action. Below we show examples of several cases that demonstrate how courts are helping to advance climate justice and emission reduction. Court rulings not only impact individual cases and individual litigants but have been shown to shape understandings and narratives of climate justice and human and environmental rights, raise awareness, inform policy and initiate social change (Boyd et al., 2021; Setzer & Higham, 2022). With their rulings, courts can have far-reaching impacts and their role is becoming increasingly important as climate litigation continues to grow (Setzer & Higham, 2022).

Moreover, without national and international non-judicial mechanisms, such as a functioning fund for Loss and Damage, and in the absence of support from other institutions, climate litigation against emitting companies and countries is often the only way to achieve climate justice. Without clear adaptation goals and compensation explicitly excluded from Loss and Damage discussions, courts are often the only way to claim compensation for loss and damage or adaptation support (Stuart-Smith et al., 2021). However, none of the latter attempts has been successful so far and a look at the number of climate lawsuits since 2015 in the Climate Change Laws of the World database shows that climate lawsuits reflect what is generally observed in international climate policy: stronger progress and action on mitigation (347 cases), while adaptation (79 cases) and loss and damage compensation (18 cases) play a less important role. There are a number of reasons for this imbalance, which are outlined in the next paragraphs.

In April 2021, the German Constitutional Court in *Neubauer et al. v. Germany* ruled that the German climate law was insufficient to meet their Paris Agreement commitments and in particular postponed too much of the necessary mitigation actions for the years after 2030, to the detriment of future generations. In the same year, the Hague District Court (Netherlands) in *Milieudefensie et al. v. Royal Dutch Shell*, ruled Shell's mitigation aims as incompatible with the Paris Agreement. These two of many examples show that climate litigation has gained a role as an important component of achieving ambitious climate goals outside the UNFCCC negotiations.

Crucially they are not independent of the negotiations. In successful climate cases, such as *Urgenda* versus *The Netherlands*, IPCC reports are used as an authoritative source of quantitative scientific evidence. *Milieudefensie v Shell* used the IPCC Special Report on 1.5C to argue for a 45% cut in emissions by 2030 and in *Australia Gloucester Resources Limited v Minister for Planning* (2019) used the IPCC reports to evidence the argument that all additional emissions matter. That these cases were successful is due to the Paris Agreement, as a binding international treaty for the countries that have ratified it, laying out clear, binding goals and setting normative expectations and shared understanding (Bodansky & Rajamani, 2019). The legal obligations of the agreement and their implementation in national laws together with the science underpinning these goals, allow courts to clearly measure when countries or companies act in a way that contradicts these goals. Overall, the number and success rate of mitigation cases is expected to rise. On the one hand, due to the growing societal awareness that mitigation measures are undelayable and on the other hand the precedence each new case creates in how to interpret the scientific evidence in view of the international agreement and national laws and constitutions allows other cases to build on the same argumentation.

In contrast, lawsuits for adaptation and loss and damages have so far not been able to prevail in the courts. Especially in the past, procedural requirements posed a challenge to the admission of cases (Burger et al., 2020; Stuart-Smith et al., 2021) and, as argued in Otto et al., 2022 a social narrative that saw adaptation and resilience building firmly outside of courts. Only in the few occasions when cases were admitted, the evidence became relevant and has been put under scrutiny. Proving causality requires linking impacts to climate change, but also disentangling all relevant factors for risks and impacts that depend on exposure and social vulnerability besides the climatic impact drivers (Stuart-Smith et al., 2021). However, while strong scientific evidence on these aspects is now becoming available, as discussed in Section 3, this is relatively new. Crucially, the current prevailing framing of climate change in society and in the courts as a problem predominantly of the future lends less legitimacy to adaptation and loss and damage cases than to mitigation cases and hinders lawyers and judges to use strong scientific evidence (Otto et al., 2022).

There is however a growing body of literature showing how admissibility and evidentiary problems can be solved in many cases and contexts (Marjanac & Patton, 2018; McCormick et al., 2017; Minnerop & Otto, 2020). Recent developments in climate science (Section 3), particularly attribution science, and major

assessment reports such as the recent IPCC AR6, provide the latest scientific basis for attributing climate impacts and damages to anthropogenic climate change (Otto et al., 2022; Stuart-Smith et al., 2021). In many cases, this research could already be utilised for meeting admissibility and passing causality requirements; however, there are few precedencies of the science actually being used to support the court ruling, an example of using attribution science as part of the evidence is *Bushfire Survivors for Climate Action Incorporated v Environment Protection Authority* in Australia. Formally this is a mitigation case, but the argumentation used the fact that climate change was one causal driver of the 2019/2020 bushfires, shown by (van Oldenborgh, Krikken, et al., 2021), as justification to demand more stringent mitigation goals. Analysis of over 80 climate litigation cases has shown that the available evidence has in many cases not been used to the detriment of the cases' outcomes (Stuart-Smith et al., 2021). To this date, there is no successful landmark case on adaptation and loss and damages, however, there are promising cases such as *Lliuya v RWE* that use the latest evidence to establish standing and are currently subject to causality tests for which climate science provides evidence. Independent of the outcome, this case already provides a precedent of how evidence of the role of climate change with respect to materialised (loss and damages) or potential (adaptation) impacts can be used in front of courts.

The success of mitigation cases has shown that law can contribute to a carbon-neutral future. It is now time for the courts to also contribute to a carbon-neutral future that is fair and just (Otto et al., 2022). The hurdle, that the lack of evidence has provided, is shrinking (Section 3) and cases like the one against RWE, as well as a case filed in Switzerland by four inhabitants of the Indonesian island of Pari against the Swiss-based major buildings materials company Holcim to request compensation for climate damages, are evidence that courts start accepting cases based on impacts of climate change. This means judges and lawyers will interpret the evidence and design rules and metrics that count as proof. The courts in this case would be ahead of climate policy, in contrast to the mitigation cases where metrics were set out first by the IPCC. Independent of whether this is societally desirable, given ongoing cases, it is inevitable that courts will interpret the evidence and thus accept one possible metric over another. Even if such standards are designed to meet legal requirements, they can inform other use cases, such as a Loss and Damage Fund (see Section 4). Different jurisdictions may develop different legal and scientific standards, potentially adding to the complexity of providing the relevant evidence. There is a danger that the absence of international policies and targets

leaves room for judges and lawyers to interpret and shape such rules and standards in different ways and it cannot necessarily be concluded that judges and lawyers will use their freedom to fill the gaps in favour of climate justice. This raises the broader question of how much more democratic legitimacy is needed for policies, targets and metrics for adaptation and loss and damage.

It is further important to highlight that although cases exist for which specific and contextualised scientific evidence of climate change impacts are available that could help the lawsuits succeed, there are remaining legal challenges across different jurisdictions (Setzer et al., 2022; Stuart-Smith et al., 2021), which are that there are not enough resources available to provide the specific evidence required by courts and it is unrealistic that every affected party will have the means (e.g. to cover initial legal costs) to make use of climate litigation. Moreover, plaintiffs would have to sue a large number of individual issuers in order to obtain any relevant part of the compensation for adaptation or loss and damage (Lliuya claims \$20,000 from RWE based on its 0.5% contribution to historical emissions). Moreover, in some situations adaptation and compensation for occurred losses and damages are already needed today, so lawsuits lasting multiple years—the ongoing case of *Lliuya v RWE* was opened in 2015—are just not feasible to bring wide-scale climate justice if their immediate impact is limited to the individual cases.

In other words, the courts will not make addressing Loss and Damage within the UNFCCC superfluous, but they could be an important lever in solving the current evidence problem. However, solutions will be different depending on the jurisdiction and might not end up supporting the most vulnerable societies, which contrasts with the explicit aim of Loss and Damage within UNFCCC. Thus, climate litigation is not a panacea for global climate justice. However, the rulings that come out at the end of these lawsuits have the potential to define what climate justice means for these cases and what evidence is required to achieve it. In this way, individual court cases can set the stage and lay the foundation for a fund to address Loss and Damage that can apply the outcomes, that is metrics, evidence, eligibility and liability, more broadly to make funds available more quickly and widely.

It is important to highlight that identifying an evidence base for the role of climate change in the hazard can only be the first step towards evidencing Loss and Damage in a political context, where the next, and arguably more complex step is concerned with ethical considerations relating to the very unequal capacities in undertaking scientific studies (Otto et al., 2020). In the following section, we focus on the hazard and elaborate on the ethical and justice aspects in Section 4.

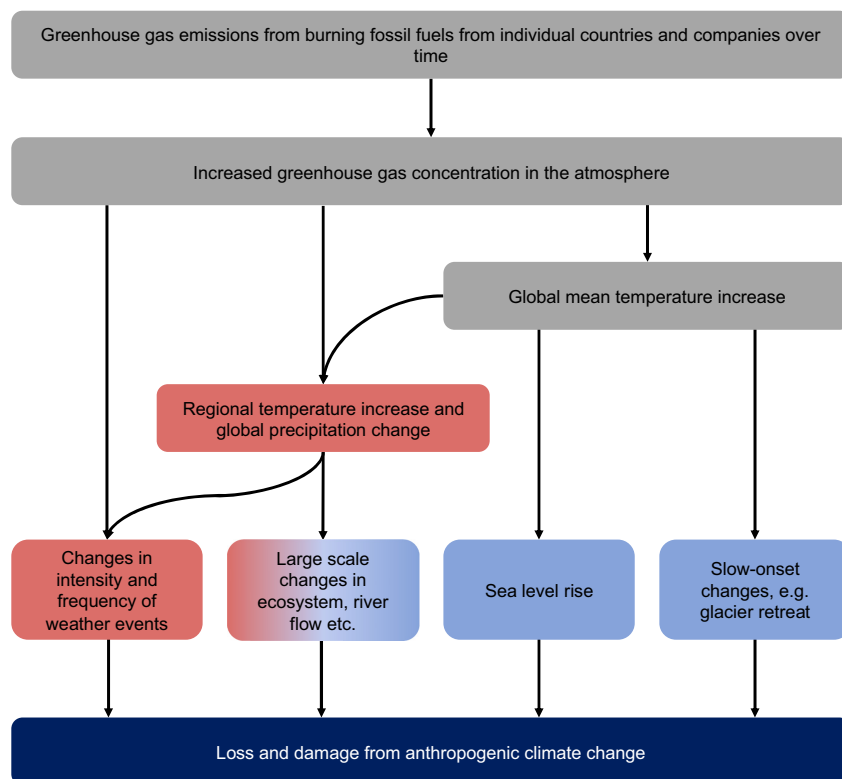
### 3 | THE NEW SCIENTIFIC EVIDENCE BASE

While the attribution of global warming to anthropogenic activity is the very basis of the United Nations Framework Convention on Climate Change (UNFCCC) and the science has long underpinned international governance of climate emissions, a similarly strong evidence base for the attribution of slow-onset and extreme events has seemed out of reach and long thought impossible, even by scientists. This, however, has dramatically changed with the publication of the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC) which provides a synthesis of attributable changes in extremes in regions across the world (Masson-Delmotte et al., 2021). The report provides a core part of the evidence base now available.

Figure 2 provides a visualisation of the skeleton of this evidence base, the causal chain from emissions to slow-onset and extreme events. In both cases, slow-onset and extreme events, tools and evidence does exist, which is, however, far from comprehensive. As challenges and advancements are similar, we focus here only on extreme events to demonstrate that our ability to measure the consequences of climate change has improved considerably.

Climate change manifests in part through more intense extreme weather events, including heatwaves, droughts and heavy rainfall. This leads to impacts upon people, property and nature that would not have occurred in the absence of these increases in events' likelihood and intensity. Unlike some other impacts of climate change, extreme weather events are manifesting on immediate timescales and changes in extremes are poorly described by the climatological means studied in many climate projections. It is now possible to causally link individual extreme weather events to anthropogenic climate change through the emerging science of event attribution (quantitatively and qualitatively) and causal network assessments (qualitatively) (Kretschmer et al., 2016). Developed earlier this century, extreme event attribution has become a rapidly growing field of science which assesses the role of anthropogenic climate change in heatwaves, flooding, drought and other weather events around the world (Clarke et al., 2022; Otto, 2017; Otto et al., 2016; Stott et al., 2016). It has demonstrated that human-caused greenhouse gas emissions have contributed to many high-impact events in recent years by increasing their frequency and intensity.

Identifying the relationship between climate change, specific extreme events and their impacts remain however challenging. On the one hand from a scientific perspective, where in particular extreme events occurring in data-poor regions and the global South more



**FIGURE 2** Chain of causality of how greenhouse gas emissions cause loss and damages. The grey boxes indicate the main driver of regional impacts. The red and blue boxes indicate impacts that scale (some faster, some slower and some at the same pace) with global mean temperature changes (red) and those that have a lagged response time (blue). Losses and damages result from both types of impacts, indicated in dark blue. Adapted from Otto et al., 2022.

generally have been barely studied, due in part to data and capacity issues (F. Otto et al., 2020). Several publications have recently discussed what is currently possible to say from a scientific point of view (Boyd et al., n.d.; Clarke et al., 2022; Harrington et al., 2022; Jézéquel et al., 2018; Otto et al., 2022). (Ekwurzel et al., 2017) and (Otto et al., 2017) have explored scientific groundwork for tracing emissions sourced from industrial carbon producers to specific climate impacts and opened up a discussion on the attribution of historical responsibilities for climate change (Lott et al., 2021). Individual extreme events lead to loss and damage in communities and societies, but impacts take many different forms, ranging from an increased mortality rate to lower crop yields to damages to infrastructure, requiring different scientific methods and thus making a widespread assessment challenging; at the same time, it often takes the occurrence of such events to understand vulnerabilities and disproportionate sensitivities of different groups. However, these advances in science have not been recognised by large parts of society, including the courts (Stuart-Smith et al., 2021). This means that decisions on adaptation interventions and loss and damage actions undertaken now are not based on the best available evidence, potentially with particular disadvantages to the most vulnerable in society through maladaptation (Eriksen et al., 2021).

Some researchers and practitioners have questioned the value of pursuing extreme event attribution. (Trenberth, 2012), for example suggests that all weather events are now affected by climate change, due to the warmer and moister atmosphere. Given the challenges of modelling specific weather events, attribution analyses might yield estimates of the influence of climate change that are too conservative (Diffenbaugh, 2020; Lloyd & Oreskes, 2018; Lloyd & Shepherd, 2020; Mann et al., 2017).

Another note of caution about attribution has arisen from experts in climate change adaptation and disaster risk (e.g. Hulme et al., 2011; Mechler & Bouwer, 2015), who suggest it could lead to an unproductive 'blame game' or put too much emphasis on the climate and the role of fossil fuel emitters, and too little on vulnerability and local risk governance. However, even among those who have expressed caution (e.g. Shepherd, 2016; Trenberth et al., 2015), interest and engagement with the science grows among experts, the public and governments. In particular, the publication of the IPCC's Sixth Assessment Report (IPCC, 2021) highlighted, which was demonstrated by (Jézéquel et al., 2018), that different approaches and views on attribution are not only compatible but complementary but also less different than the scientific debate might suggest. All approaches would be most

useful if including assessments of the role of vulnerability (Stone et al., 2021; van Oldenborgh, van der Wiel, et al., 2021).

To summarise, it is now possible to conduct attribution studies for a large range of extreme events across the world using a variety of data and approaches. However, there is no systematic attempt to undertake such studies, thus a discrepancy between individual methodologies and framing leads to often incomparable and very uneven findings across types of extremes and geographies. In other words, while it is possible to provide a high-level overview of some of the impacts of climate change today (Clarke et al., 2022; Seneviratne et al., 2021), this is not the case for individual countries or more complex extremes. The tools do exist but have not been applied comprehensively. Without an authoritative source to identify metrics, it is unlikely that it will emerge soon from the scientific community itself. This is, however, where the courts could play an important catalysing role. If judges in the next years are faced with more and more cases based on attribution studies, precedents will emerge of which ones are deemed 'good enough' to evidence a substantive role of human-induced climate change in extreme weather events that led to damages. We argue in the following section that this is not sufficient for a fair and just compensation fund on Loss and Damage, but an important step to categorise hazards and losses and damages.

## 4 | INFORMING LOSS AND DAMAGE

Despite slowly increasing global efforts to mitigate and adapt to climate change, extreme weather events are growing in magnitude and frequency, and slow-onset events like sea level rise threaten coastal regions and societies (Masson-Delmotte et al., 2021). At the same time, calls for tackling equity and justice conditions across scales (Newell et al., 2021; Sultana, 2022) reach beyond academia and are, for example a key driver behind the implementation of the Paris temperature goal. Failures to mitigate greenhouse gas emissions or adapt are resulting in loss and damage from the impacts of climate change (Boyd et al., 2021). Loss and Damage is also the subject of the UNFCCC Warsaw International Mechanism and an article of the Paris Agreement. While there is no agreed-upon definition of Loss and Damage (Boda et al., 2021; Boyd et al., 2017; James et al., 2019), climate impacts are ultimately the result of the realisation of differential vulnerability, differential distribution of hazards (e.g. tropics, coastal areas) and exposure (e.g. development in floodplains, close to coastal cliffs) (Dorkenoo et al., 2022). Using science to equalise the evidence base is thus the anchor point of a new agenda of climate justice (Boyd et al., 2021) and for the potential support and compensation of losses

and damages from climate change suffered by people and groups in vulnerable situations. This has been the rationale behind including Loss and Damage in the UNFCCC framework in the first place but has also driven the implementation of the Loss and Damage fund following COP27.

The UNFCCC Loss and Damage Fund is a financial mechanism to be established under the United Nations Framework Convention on Climate Change (UNFCCC) to provide financial support for developing countries that are facing losses and damages from climate change. The fund is going to be administered by the Executive Committee of the Warsaw International Mechanism on Loss and Damage, which is responsible for developing the rules and procedures for the fund, as well as for guiding the use of funds. The timeline is tight for a difficult challenge, given that not even the term Loss and Damage is officially defined within the UNFCCC framework.

The rules and procedures that would need to be developed in order for the fund to be operational include criteria for (i) eligibility both in terms of types of losses and damages and entities to receive funding, (ii) types of support available, and (iii) the application process.

Furthermore, of course, the UNFCCC Parties (i.e. countries that have signed and ratified the UNFCCC) would need to provide financial contributions to the fund, either through voluntary contributions or through the provision of financial resources from existing mechanisms, such as the Green Climate Fund. This is essential for the fund's existence and the contributions per country to the fund could be based on historic emissions, for which clear metrics and inventories exist. However, especially given the long history of the ignorance of Loss and Damage in climate policy, political questions remain about whether and to what extent countries will be willing to contribute.

Similarly, which developing countries will be eligible for the fund could also be based on criteria and considerations already in use within the context of the UNFCCC, e.g. 'least developed countries'. However, depending on the size of the fund in the long and short term, there will still be a need for prioritisation. From an ethical point of view, this should probably be based on needs rather than evidence of hazards. However, as recent literature on maladaptation (Eriksen et al., 2021) has shown, without knowledge of how climate change affects precipitation patterns and temperature extremes or other crucial aspects relevant to the local context, implementing the right adaptation measures is complex. As a result, farmers might invest in crop varieties or irrigation systems that are ill-suited for actual future conditions or only for average conditions but leading to decreased yields, increased water stress and economic losses because changing extremes were not considered. The specific impacts of climate change are important to avoid unintended

consequences and ensure that adaptation measures effectively address vulnerabilities. Even if, as argued e.g. in King et al. (2023) the science of event attribution is not mature enough to inform individual decisions on Loss and Damage in a comprehensive way, knowing uncertainties and what can and cannot be said in the face of extreme droughts and floods with currently available data and methods is important to not fall into maladaptation traps.

Most importantly though, evidence on changing hazards and associated losses and damages is required to determine eligibility. The rules for a Loss and Damage fund would need to specify the types of losses and damages that are eligible for support from the fund, such as losses from extreme weather events, impacts on livelihoods and food security, or losses of natural habitats and biodiversity. This is where, as discussed above, evidence is currently lacking and if existing at all far from being comprehensive, which is also reinforced by the absence of agreed-upon metrics to measure loss and damage from climate change. This raises a couple of questions and uncertainties. For example, whether it will be necessary—in order to be eligible for the fund—that the causing extreme event needs to be demonstrably have been influenced by climate change (e.g. through an attribution study). This is theoretically important and would need to be discussed when setting up rules. Scientists, including these authors, have argued in the past that such scientific evidence is important from an ontological point of view (Thompson & Otto, 2015). Practically, however, the current and available evidence in the near future cannot support such requirements and would severely disadvantage developing countries (Olsson et al., 2022; F. Otto et al., 2020), that is those that are supposed to receive support from the fund. Thus, leading to the conclusion of King that event attribution ‘is not ready for a major role in loss and damage’. This is certainly true when it comes to deciding on a specific instance of incurred losses, the size of compensation required etc., all of which are not scientific but political questions. In general, deciding if damages from a certain type of hazard are eligible is difficult without taking scientific evidence into account. Here, an example is cold waves. Cold waves do occur and often lead to considerable damages (Ma & Zhu, 2019), overall, cold waves are getting less cold and less frequent with climate change (van Oldenborgh et al., 2019), but there are exceptions (Vautard et al., 2023). If cold waves would be included in the eligible types of hazards pay-out requests could be huge and leave less funding available for, say droughts, where the role of climate change is often unclear too. Not entertaining these questions when setting up a fund would lead to implementation problems later, and probably be

solved via the courts if a fund is set up without clear metrics and criteria. An outcome that would delay help in the face of damages and thus particularly hurt the most vulnerable the fund is set out to support. Thus, evidence from attribution does need to be taken into account.

It is impossible to develop the science that has not been regarded as necessary for decades within a year. Hence, a pragmatic approach is required that on the one hand allows making use of the available evidence but on the other hand ensures that those most vulnerable and least responsible for historic emissions can access funding to build resilience. In other words, some level of evidence will need to be required to identify the types of hazards generating loss and damages which are eligible for the fund, for example heat waves and heavy rainfall as well as sea level rise-related impacts are the easy ones most clearly and globally linked to climate change (IPCC, 2021; Clarke et al., 2022). Other events need careful consideration, such as different types of droughts or highly impactful events like Glacier Lake Outburst Floods (GLOFs), both of which have devastating consequences but are less clearly attributable, either because of the absence of a climate change signal (Seneviratne et al., 2021) or lack of data and research.

These are the considerations most strongly in need of scientific evidence to define eligibility, but further rules need to be established to determine the types of support available. The rules would need to specify the types of activities that can be funded through the fund, such as early warning systems, disaster risk reduction measures or support for the rehabilitation and reconstruction of infrastructure. Further funding rules are required to, for example specify the maximum amount of funding that can be provided to each eligible country, as well as the maximum duration of support.

In addition, there are many more rules and considerations the UNFCCC Loss and Damage Fund would need to provide that are less reliant on evidence. For example, a detailed and transparent framework that not only allows for the provision of financial support to developing countries facing losses and damages from climate change but also clearly links to other processes in the UNFCCC such as the global stocktake. None of these challenges is insurmountable, but the timeline renders in particular the development of metrics to measure impacts from anthropogenic climate change difficult, considering timelines required to, for example produce IPCC reports. The fact that several ongoing court cases as well as those that are currently being prepared require similar evidence could however speed up, at least in the short term, the usual UNFCCC timescales. If judges across jurisdictions find a way to interpret existing evidence consistently, subsequent IPCC reports could build on these.



## 5 | CONCLUDING REMARKS

Adaptation and loss and damage have received much less funding and attention in policy, law-making and the courts than mitigation. We argue that this is in part due to the very different scientific evidence base for adaptation and loss and damage compared with that for mitigation. Partly, this is due to the different nature of the problem which means metrics and inventories will look very different to those for mitigation. However, we have shown above that in the last few years, a large body of evidence has been developed that now allows to evidence the complete chain of causality from emissions to changes in the weather and, less comprehensively, resulting impacts and damages.

This evidence has considerable gaps and methodologies are currently not consistent, but at this point in time there is no scientific reason for the absence of an IPCC task force on climate impact metrics that would mirror the existing one on emission metrics (the Task Force on National Greenhouse Gas Inventories (TFI) which was established in 1998). Such a task force could close the evidence gap needed for both informing adaptation as well as achieving climate justice and developing a framework for a systematic assessment of climate impacts around the planet.

In the case of mitigation, we have shown that the rich evidence preceded the development of mitigation policies, in the Paris Agreement and national policies, for which countries and corporations could be held responsible in the courts. In the case of adaptation and loss and damage, the situation is reversed. Goals on adaptation are implemented in policy and a Loss and Damage fund has been established; however, comprehensive metrics are lacking. This means that policies exist but lack teeth. We thus hypothesised that the courts again could play an important role in this case not in helping to enforce and interpret existing policies, but be at the forefront in designing metrics and agreed-upon methodologies for measuring the impacts of human-induced climate change. Comprising the risk though that such metrics and evidence requirements are unfavourable for global climate justice.

With the Loss and Damage Fund established, a new body of scientific evidence introduced in the IPCC and climate litigation being recognised as a legitimate root to justice the timing could not be better to finally put adaptation and loss and damage on more equal footing with mitigation. It needs a wide recognition of the opportunities and risks however for this to take place. There are pitfalls in designing the rules of the fund, especially how eligibility is determined, which can be avoided by analysing the current climate litigation on adaptation and loss and damages. Such lawsuits can create important precedencies, provide climate justice in individual cases and send strong signals; however, there are legal, logistical and evidentiary limits

to achieving wide-scale justice. This bears important implications for the Loss and Damage Fund: to be impactful, it must be practical. If the hurdles are too high, it remains a nice idea with good intentions.

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### DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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