Concept of loss and damage of climate change - a new challenge for climate decision-making? A climate science perspective

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Published online: 30 Jul 2014.

To cite this article: Swenja Surminski & Ana Lopez (2014): Concept of loss and damage of climate change - a new challenge for climate decision-making? A climate science perspective, Climate and Development, DOI: 10.1080/17565529.2014.934770

To link to this article: http://dx.doi.org/10.1080/17565529.2014.934770
Loss and damage (L&D) of climate change is a relatively new work stream of the international climate change regime. Lacking a clear official definition, L&D has triggered a debate about framing the topic, incorporating technical aspects of disaster risk reduction (DRR) and climate change adaptation as well as political considerations such as the idea of compensation for vulnerable countries. This paper reviews the implications of L&D for decision-making with a special focus on the role of climate science. We identify three broad policy goals embedded in the discussion: creating awareness about the sensitivity of human and natural systems to climate change; developing risk reduction and risk management approaches to enhance adaptation, reduce vulnerability and build resilience and informing compensation mechanisms. For all of these, an understanding of the current and future climate-related L&D is needed. Existing decision-making frameworks can help deal with uncertainties and avoid a ‘wait and see’ mentality for most L&D decisions. The compensation component of L&D, however, offers a different dimension to the climate change discussion. While recognizing the political and moral reasons driving the debate around compensation, an increased focus on the complex and possibly unsolvable attribution question might put on hold efforts to integrate adaptation to climate change with wider development aims and DRR, blocking necessary action.

Keywords: loss and damage; climate decision-making; uncertainty; climate change attribution

1. Introduction

The concept of loss and damage (L&D) of climate change has emerged as one of the more recent work streams of the international climate change regime. While initially being promoted and debated by only a handful of experts, it gained an official status within the United Nations Framework Convention on Climate Change (UNFCCC) following the adoption of the Cancun Adaptation Framework (CAF), an outcome of the 16th session of the Conference of Parties in 2010. The CAF highlights the need to strengthen international cooperation and expertise to understand and reduce L&D associated with the adverse effects of climate change (UNFCCC, 2011a). This led to the initiation of a new work programme on L&D by the Subsidiary Body for Implementation. This process culminated in the establishment, most recently at COP 19 in Warsaw, of the ‘Warsaw international mechanism for loss and damage’ (UNFCCC, 2013). Heralded as one of the few achievements of the COP 19, this continues to bring attention to the topic. While the Warsaw agreement suggests that there is a growing acceptance of international support for climate change victims within the international climate change policy community, it is also clear that there is no common ground on compensation and liability for L&D.

At the same time, researchers and practitioners struggle framing the idea of L&D from climate change, as a clear official definition of L&D is lacking. The UNFCCC provides a baseline, but still leaves room for interpretation (UNFCCC, 2012a). The topic is situated somewhere in the sphere of climate change adaptation (CCA) and disaster risk reduction (DRR), driven and dominated by a small group of actors, while the wider climate change community appears to have differing considerations about the scale and relevance of this topic.

Some observers consider L&D as a predominantly political construct, focused on the concept of compensation – aimed at transferring funds to those who are experiencing climate change L&Ds (Hyvarinen, 2012). Others seem to see it as a more targeted approach of dealing with negative climate change impacts embedded in the climate adaptation methodology (Mechler, 2013), while yet other observers highlight L&D as an approach for dealing with residual...
Assessing and addressing L&D requires decisions to be made – on a wide range of topics and at various levels of governance, ranging from the global level, where UNFCCC negotiators need to decide how to take this topic forward, how to allocate funding and to establish possible institutional frameworks around L&D, all the way through to the local level, where communities need to understand and manage changing risks.

All these aspects have to cope with data constraints and uncertainty in climate and socio-economic trends, the political framing and the lack of clear boundaries, as well as the multi-dimensionality of establishing cause and effect of climate change L&D. This creates challenges for decision-makers at all levels and could potentially lead to inactivity if not addressed properly.

While the topic of decision-making under uncertainty has been receiving significant attention in the context of CCA (Dessai & Hulme, 2007; Gilboa, 2009; Lempert, 2002; Lempert & Collins, 2007; Ranger, Millner, Lopez, Ruta, & Hardiman, 2010b; Ranger et al., 2010a), it has remained under-explored for L&D. In this paper, we aim to fill this gap by discussing the role that existing approaches to decision-making could play when addressing each of the three policy goals embedded in the climate change L&D discussion: creating awareness about the sensitivity of human and natural systems to climate change; developing risk reduction and risk management approaches to enhance adaptation, reduce vulnerability and build resilience, and informing compensation mechanisms.

We start by reviewing current knowledge of L&D, reflecting on the existing efforts to frame it and on the technical challenges that have been identified in the literature. We then discuss how climate science uncertainties and limitations affect the assessment of risk and the implications of this for L&D decision-making. We conclude with a commentary and outlook for the ongoing discussions about L&D.

2. A review of the current L&D policy field

L&D of climate change officially entered the UNFCCC discussions in 2007,1 but the concept itself has a far longer history. Growing awareness of the projected negative impacts of climate change has been at the core of the emerging mitigation and adaptation efforts. In the early adaptation literature, there was reference to the residual impacts after mitigation and adaptation were carried out. In this context, L&D associated with extreme events appear as a demonstration of the limits to current levels of adaptation (Smit, Burton, Klein, & Wandel, 2000; Smithers & Smit, 1997).

At a policy level, efforts to formally address damages related to climate change incurred by developing countries can be traced back to 1991, when the Alliance of Small Island States (AOSIS) proposed insurance, related actions and compensation arrangements in the third session of the Intergovernmental Negotiation Committee for a Framework Convention (Millar, Gascoigne, & Caldwell, 2013).

Since then, there have been a relatively small but growing number of stakeholders engaged in this area. Those involved in the negotiations such as AOSIS, the Least Developed Countries Group and national governments of vulnerable countries, such as Bangladesh, collaborate with think tanks and advocacy groups, such as Munich Climate Insurance Initiative (MCII), Germanwatch, the Overseas Development Institute and others2 – producing reports, guidance notes and influencing the negotiations.

The current climate change L&D literature offers input to two broad aspects: the framing of L&D in the wider context of CCA and DRR, and the identification of technical challenges for assessing and addressing L&D, including questions of implementation.

2.1. The framing of L&D in the wider context of CCA and DRR

There is wide agreement in the literature that climate change L&D has not been properly framed and defined (see, e.g. UNFCCC, 2012a, 2012b). While the same can be said about the concept of adaptation (Schipper, 2006), the unclear terminology and the multi-dimensionality of L&D continue to invite a range of different interpretations. The Bali Action Plan referred to ‘loss and damage associated with climate change impacts in developing countries that are particularly vulnerable to the adverse effects of climate change’ (UNFCCC, 2008a). This was then specified in more detail in the CAF – stating that approaches to address L&D should consider climatic impacts, ‘including sea level rise, increasing temperatures, ocean acidification, glacial retreat and related impacts, salinization, land and forest degradation, loss of biodiversity and desertification’ (UNFCCC, 2011a). A recent UNFCCC-commissioned literature review on L&D approaches (UNFCCC, 2012b) uses the following working definition of L&D: ‘the actual and/or potential manifestation of impacts associated with climate change in developing countries that negatively affect human and natural systems’. Here, the impacts of climate change include those caused by changes in intensity and frequency of extreme weather events, as well as slow-onset events (such as monotonic sea level rise) and the combinations of these two. It differentiates between ‘loss’ (negative impacts in relation to which reparation or restoration is impossible, such as loss of freshwater resources) and ‘damage’ (negative impacts in relation to which reparation or restoration is possible, such as windstorm damage to the roof of a building or damage to a coastal mangrove forest as a result of coastal surges) (UNFCCC, 2012b).
Overall, we notice two different dimensions when framing L&D of climate change: the technical concept, which looks at tools and processes to assess and manage risks, and the political dimension, where boundaries to climate adaptation, compensation and equity play a role. Linked to the political concept is the legal understanding of L&D, asking for cause and liability of these impacts, which might be relevant for agreeing funding of L&D across the international community and deciding on potential compensation arrangements. The consideration of compensation arrangements for climate change has a long history – triggered by the emergence of early assessments of the potential damages arising from climate change (such as Ayres & Walter, 1991). The discourse has evolved around different perspectives, e.g. compensation can be considered in a legal context (see, e.g. Tol & Verheyen, 2004) or in terms of financial arrangements (see the discussion about insurance in Brown & Seck, 2013), from a humanitarian perspective, in non-economic terms or in the broader context of development (see Farber, 2008; Sprinz & von Bünau, 2013 for a more detailed discourse of climate compensation, as well as O’Brien et al. (2012) for a reflection on compensation within the Intergovernmental Panel on Climate Change (IPCC)’s work on extreme events).

The technical dimension of L&D has its roots in the general risk management methodology, based on a terminology widely applied in DRR and more recently in CCA. The UNFCCC (2012a) explores the terminology in detail – highlighting different approaches to L&D as currently applied to DRR and CCA. Most broadly, ‘damage’ is seen as the physical impact and losses as monetized values, which could be direct or indirect in the form of economic follow-on effects (UNFCCC, 2012a). Here, the focus is on categorizing, assessing and projecting impacts of events – mainly in the context of disasters, but also in the context of climate change implications for sudden-onset and slow-onset impacts, over a range of time scales, and including direct and indirect economic losses, loss of lives and damages to and loss of eco-system services. In the broader climate change context, L&D is often described as the third cost element of climate change, as outlined by Klein et al. (2007) (see also van Vuuren et al., 2011): mitigation costs, adaptation costs and residual damage. In this context, L&D is seen as addressing those losses that are likely to occur despite adaptation and mitigation efforts. This academic exercise of framing L&D is replicated among policy-makers – where different interpretations of scope and concept are apparent among UNFCCC Parties, as highlighted by Kreft (2012, p. 3):

Some Parties suggest that L&D is the residual risk when mitigation is insufficient, and when the full potential of adaptation is not met (Norway) while others frame L&D as the residual after mitigation and adaptation choices have been made (Gambia). Ghana proposes that the concept of loss and damage from the adverse effects of climate be viewed as additional to adaptation focusing on challenges of both identifying and addressing the instances when adaptation is not longer possible. However, Bolivia maintains that loss and damage from the adverse effects of climate change concept is beyond adaptation, and as such is additional to adaptation, focusing on challenges of both identifying and addressing the instances when adaptation is not longer possible.

In addition to the above, a small number of case studies are emerging considering L&D in the context of certain countries or social groups – e.g. the work of the Loss and Damage in Vulnerable Countries Initiative, aimed at supporting the international negotiations on L&D through assessment of initiatives on the ground (see Shamsuddoha, Roberts, Hasemann, & Roddick, 2013; Warner et al., 2012).

2.2. The identification of technical challenges for assessing and addressing L&D, including questions of implementation

Beyond the efforts to frame L&D, most of the debate has been on tools and approaches for assessing and addressing L&D, in line with the thematic areas to be considered in the implementation of the UNFCCC’s work programme (UNFCCC 2011b):

(i) Assessing the risk of L&D associated with the adverse effects of climate change and the current knowledge on the same.

(ii) A range of approaches to address L&D associated with the adverse effects of climate change, including impacts related to extreme weather events and slow-onset events, taking into consideration experience at all levels.

(iii) The role of the Convention in enhancing the implementation of approaches to address L&D associated with the adverse effects of climate change.

(Source: UNFCCC, 2011b).

Two recent UNFCCC reports (UNFCCC, 2012a, 2012b) highlight some technical challenges and limitations for assessing and addressing L&D, such as the difficulties of quantifying hazard and vulnerability, estimation of climate-induced losses and the consideration of direct and indirect losses, including non-monetary losses.

To inform decision-makers, the UNFCCC has commissioned work to address these three areas.

The UNFCCC technical report 2012 (UNFCCC, 2012a) investigates tools and methods to assess L&D risks (Thematic Area I). The report concludes with a list of challenges when applying existing risk assessment for
3. L&D from a science point of view – the challenges of assessing the risk.

Risk is a function of hazard, exposure and vulnerability. Therefore, any attempt of assessing the risk of L&Ds from climate change needs to incorporate two key components and illustrate their interplay: data on vulnerability and exposure, as well as information on the climatic hazard, including current climatic variability and possible future climatic changes, and information about the vulnerability and exposure. A significant challenge for L&D is then the uncertainty in this information, which does not just stem from climate change; the actual losses and damages are often heavily determined by the vulnerability and exposure (IPCC, 2012). In fact, the climate dimension just adds to the uncertainty derived from the wide range of socio-economic and environmental factors considered, often referred to as the ‘cascade of uncertainty’ (Schneider, 1983) or the ‘uncertainty explosion’ (Henderson-Sellers, 1993).

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for L&D assessments. A further limitation to current understanding of exposure and vulnerability interplay stems from the fact that the majority of existing risk assessment tools and methods only examine the status quo without reflecting on the role of future trends, e.g. in urbanization, poverty or social cohesion (Bouwer, 2013; UNFCCC, 2012a).

The information about the climate hazard relates to the physical phenomena, such as large cyclonic storms or long-term reductions in precipitation, and some of their consequences, such as flooding or water resources system failure. This hazard information constitutes the input to estimate the magnitude and frequency of damaging meteorological events in DRR approaches, or future projections of climate risks to inform CCA. From the (physical) science point of view, there are challenges to estimate the hazard part of the total risk common to all interpretations of L&D.

To evaluate the current and changing likelihood of climatic hazards, different sources of information are employed (IPCC, 2007a, 2007b, 2012). Historical records of climate variables, such as temperature or precipitation, are used to estimate current climate variability. Estimates of changes of these variables in the future are provided by climate models. Impact models are then employed to evaluate how changes in climatic variables will produce changes in particular natural or human systems, e.g. how changes in precipitation patterns will affect flood regimes in a given catchment.

Historical records must be accurate, representative, homogeneous and of sufficient length if they are to provide useful statistics. The value of the inferences depends on the data representing the range of possible values occurring over time. Availability and quality of data can induce large uncertainties in the estimation of current climatic hazards. While data for temperature and precipitation are widely available, other variables such as soil moisture are poorly monitored or extreme wind speeds are not monitored with sufficient spatial resolution. Palaeoclimatology can provide information about rare, large magnitude events in places where long enough observational records are not available and good proxies to estimate the magnitude of past events such as floods or droughts can be found. Palaeodata often illustrate the fact that, in many cases, the recent observational records provide very limited information about the range of the unforced natural variability in a particular location, allowing for testing the robustness of the systems under consideration even before human-induced climate change is taken into account (Benito et al., 2004).

Projections of changes in future climate are based on climate model simulations. Even though the physical and chemical processes in the climate system follow known scientific laws, the complexity of the system implies that many simplifications and approximations have to be made when modelling the system. The choice of approximations creates a variety of physical climate models (IPCC, 2007a). There are different sources of uncertainties in climate model projections. Climate forcing or scenario uncertainty is introduced by the fact that to simulate future climate, the models are run using different scenarios of anthropogenic forcings that represent plausible but inherently unknowable future socio-economic development (IPCC, 2000; Moss et al., 2008). Climate model and climate variability uncertainties are due to our incomplete knowledge of the climate system, the limitations of computer models to simulate it and the system’s nonlinearity (Knutti et al., 2007; Stainforth, Allen, Tredger, & Smith, 2007). The relative and absolute importance of these different sources of uncertainty depends on the spatial scale, the lead-time of the projection and the variable of interest (Booth et al., 2013; Hawkins & Sutton, 2009). At shorter time scales, in many cases, the current natural variability of the climate system and other non-climatic drivers of risks will have a higher impact than the climatic changes driven by changes in atmospheric concentrations of greenhouse gases. For example, in the near term, and under current climate variability, changes in exposure such as urbanization and building housing developments in flood-prone areas could increase significantly the risk of flooding and damage to the aforementioned infrastructure, independently of climate change. Over longer time scales, it is expected that anthropogenic climate change might play a more significant role.

It is clear then that any strategy adopted to manage climate hazards has to take into account the large uncertainties in climate projections and, even more importantly, acknowledge that in many cases, particularly at local scales, current modelling tools to generate projections cannot produce reliable and robust estimates of future changes (Oreskes, Stainsforth, & Smith, 2010; Risby & O’Kane, 2011).

While global climate models (GCMs) simulate the entire Earth with a relatively coarse spatial resolution (e.g. they can capture features with scales of a hundred kilometres or larger), regional climate projections downscaled from GCMs have a much higher resolution (simulating features with scales as small as a few kilometres). Downscaling can be accomplished through one of two techniques: ‘dynamical’ or ‘statistical’ downscaling (Wilby et al., 2009). ‘Dynamical’ downscaling refers to the process of nesting high resolution regional climate models within a global model, while ‘statistical’ downscaling relies on using statistical relationships between large-scale atmospheric variables and regional climate (often at the station level) to generate projections of future local climatic conditions. Downscaling approaches do not provide magical fixes to possible limitations in the data being downscaled (Kerr, 2011). In fact, the downscaling approach will only introduce one more source of uncertainty and/or ignorance in the resulting output. In this case, the generation of climate projections using downscaling techniques will
almost certainly increase the level of uncertainty in the original GCM projections, having significant effects in the estimation of probabilities of occurrence of damaging events in DRR models and climate change risk assessments.

Climate model projections provide information about climate variables, such as temperature, precipitation, sea level, etc. However, a climate risk assessment involves understanding how changes in these variables will affect particular natural or human systems. In some cases, such as with heat waves, changes in temperature are the only information needed to estimate the climatic hazard. In other cases, such as floods, an intermediate modelling step is required. This step is carried out by impact models, which are computational models that take as inputs observed or simulated climate variables, such as temperature, precipitation, soil moisture content, wind speed, etc. and use them to simulate the variables that are relevant to analyse a particular climate impact (IPCC, 2007b, 2012). For instance, extreme rainfall events can cause floods. But to estimate the extent of the flooded area, a storm water management model is used to generate the flood footprint for each particular event (Ranger et al., 2011). The limitations of impact models are similar to some of the limitations of climate models: poor representation of the physical processes involved, calibration issues and computational constraints all contribute to compounding the uncertainties in the climate inputs with the uncertainties in the impact model outputs.

In summary, a comprehensive modelling approach to assess climate change-induced hazards requires combined simulation of all the domains. For flood risk, for instance, it requires the modelling of the atmosphere and ocean, catchment river network, flood plains and indirectly affected areas. As discussed above, considerable uncertainty is introduced into each of the modelling steps involved, including uncertainties about the greenhouse gas emission scenarios, the representation of physical processes in the GCM, the characterization of natural variability, the method of downscaling to catchment scales and in hydrological model structure and parameterizations.

Therefore, the uncertainty associated with a complete model chain is large, particularly at the scale relevant for decision-making. Moreover, if the goal is to estimate the residual likelihood of the climate hazard after mitigation and adaptation, there will be one more link in the chain of uncertainties (Henderson-Sellers, 1993; Schneider, 1983), namely the possible adaptation pathways and the uncertainties associated with them, for instance, how changes in exposure and vulnerability triggered by the adopted options might feedback into the climate and societal systems.

For L&D assessment, it is therefore important to develop and integrate vulnerability and exposure scenarios with climate scenarios (Birkmann, Chang Seng, & Krause, 2011). Recently suggested ways forward focus on the need to integrate all components of risks, including an upgrading of vulnerability and exposure assessments (Huggel, Sone, Auffhammer, & Hansen, 2013; Stern et al., 2013).

The above discussion about the estimation of the climate hazard is closely related to and based on similar discussions within CCA. However, L&D also brings something distinctly unique to the discussion: embedded in the political concept of L&D is the element of compensation, which requires the possibility of estimating the attributable fraction of losses and damages to human-induced climate change. Estimations of the future likelihood of a climatic hazard do not, a priori, have any information about whether or not the event can be attributed to human-induced climate change. Since the climate varies continuously at all time scales, and usually there are many causal factors underlying an extreme event, attribution of particular weather events is very difficult; there is always the possibility that the event might have occurred even in the absence of human-induced climate change, especially in the case of current or near-term future impacts. Recently, new approaches have been developed that attempt to quantify the attributable part of the changing meteorological risk, or in other words, what is the change in the probability of occurrence of a given weather event due to human influences on the climate system (Pall et al., 2011; Peterson, Stott, & Herring, 2012; Stott, Stone, & Allen, 2004).

These approaches rely heavily on climate models to compare how the likelihood of the weather event changes with and without the influence of anthropogenic emissions of greenhouse gases. Clearly, this requires the models to be able to simulate correctly both scenarios. However, as it has been discussed already, climate models have significant limitations to simulate the climate at the scales relevant for extreme meteorological events (Trenberth, 2012; Trenberth & Fasullo, 2012) and the climate system telecommunications that could explain the extreme magnitude or persistence of some events (Trenberth & Fasullo, 2012). Moreover, the estimated changes in likelihoods rely on climate model simulations that cannot be directly validated against observations (Allen et al., 2007). Therefore, these probabilities can only be subjective Bayesian probabilities that reflect judgement about uncertainties in climate model experiments rather than robust estimates of the attributable part of changing climatic risks (Hulme, O’Neil, & Dessai, 2011).

4. Challenges for decision-makers
L&D – both as a political concept and in its technical dimension will require decisions to be made at different scales from local to global, and by a range of stakeholders. We propose three categories of decision-making goals for L&D:
• To create awareness about the sensitivity of human and natural systems to climate and the need to respond with appropriate mitigation, adaptation and DRR policies (UNFCCC, 2012d).
• To develop risk reduction and risk management responses, with the goal to enhance adaptation to reduce vulnerability and build resilience; in this case, the evaluation of climate risk is a necessary component of any adaptation options appraisal. This category has many analogies with CCA and DRR, asking how to assess and how to respond to risks.
• To inform compensation arrangements for L&D.

For all these, an understanding of the current and future scale and distribution of climate-related L&D is fundamental. As noted above, decision-makers are faced with uncertainties related to hazard, exposure and vulnerability. For some, this may prove as a potentially welcome excuse for inaction, for others this might lead to misdirected computation and data-collection exercise or to heated, almost unresolvable disputes about the underlying science. Can this potential paralysation (Dessai, Hulme, Lempert, & Pielke, 2009) be avoided? The ability to make L&D decisions depends on skills and know-how for assessing the risks and institutional capacity as well as funding to address it (UNFCCC, 2012a). But given the large uncertainties inherent to the estimation of risk, the use of a decision-making framework that can make the best use of the available information to develop strategies to reduce L&D is also the key.

In recent years, two decision-making frameworks have been developed in the context of CCA: the ‘top-down (or science-driven)’ and the ‘bottom-up (or policy-driven)’ frameworks.

The first framework focuses on climate modelling information, often downscaled, to project the impacts of climate change and then derives policies in response to these impacts. This approach has been criticized for its heavy reliance on climate projections that are limited in their ability to represent key drivers of extreme events and are not generally fit for the purpose of decision support (IPCC, 2012; Smith & Stern, 2011; Stainforth et al., 2007), and for the potential lack of robustness of the projected impacts due to different methodological issues (Hall, 2007; Merz, Hall, Disse, & Schumann, 2010; Tebaldi & Knutti, 2007).

The second framework is based on risk management approaches that start by defining the policy or adaptation goal and consider the climatic component as just one part of the whole risk faced by the system (Ranger et al., 2010a, 2010b; Willows, Reynard, Meadowcroft, & Connell, 2003). The starting point, which consists of the definition of the particular problem/decision to be addressed, includes identifying present and future climatic and non-climatic risks that make the system vulnerable, identifying institutional and regulatory constraints and identifying the possible options.

In the context of L&D, the goal could be to reduce the risk of L&D resulting from particular extreme events to tolerable levels and plan the management of the residual risk that cannot be minimized. The uncertainty in the risk information available and the prospect of this information changing in the future will require from decision-makers the need to design flexible adaptation and management pathways that allow for periodic adjustments as new information becomes available, and the possibility of changing to new routes when or if incremental adjustments are no longer considered sufficient according to the evidence available at the time (Hallegratte, 2009; Hulme, Pielke, & Dessai, 2009; Lopez, Wilby, Fung, & New, 2010; Wilby & Dessai, 2010).

It is clear that there are fundamental differences between the two decision-making frameworks described above. When we explore the relevance of these two decision-making frameworks for L&D, the following picture emerges: their application in the context of the L&D debate depends on the intended goal.

The top-down approach appears most relevant for the first goal, when the exercise of mapping climate change impacts aims to create awareness about the plausible climate change losses and damages in order to trigger policy responses (mitigation, adaptation and DRR).

For the second L&D goal, there is a strong parallel with the CCA problem: how to minimize the climate change risk to tolerable levels, and what are the options to manage what cannot be minimized. In this sense, the challenges presented by the need to reduce and manage climate change L&D are not very different to the ones presented by the need to adapt to climate change and variability. When thinking about estimation of L&D as a tool to plan for the management of the residual risk (with or without successful mitigation and previous adaptation), the ‘policy first’ approach appears as the adequate framework to address this question.

Finally, as already mentioned, the third dimension of the decision-making relevance of L&D assessments lies in the context of attribution of damages to the incremental risk caused by anthropogenic climate change. For this to be possible, the incremental fraction of L&D that can be attributable to anthropogenic climate change would need to be computable. From the point of view of the decision-making frameworks discussed above, this is very much a ‘science first’ approach with the extra requirement of a simulation of the counter factual world, i.e. an estimation of the likelihood of the event had greenhouse gas concentrations not increased during the last hundred years or so. As discussed in Section 3, the estimation of the attributable, incremental risk presents serious challenges. Some climate scientists argue that the science of
The attribution of climate events could support decisions related to obtaining compensation for damages caused by attributable natural disasters, since it potentially allows the ability to distinguish between genuine consequences of anthropogenic climate change from climate events that are a result of internal climate variability (Hoegh-Guldberg et al., 2011; Peterson et al., 2012). Other authors (Hulme et al., 2011) challenge the idea that the science of weather event attribution has a role to play in this context, in particular due to the fact that the estimated changes in attributable risks are based on climate modelling experiments which cannot provide robust answers. Therefore, relying on them to make decisions about economic compensation could be misleading. While clearly relevant for the compensation aspect of L&D, the search for evidence of the causal link, particularly in the context of single events, could lead back to a so-called ‘physicalist interpretation of disasters’ (Hewitt, 1995), and distract from the importance of recognizing risks in its totality (Hugel et al., 2013). This might put on hold efforts to integrate climate change with wider development aims and DRR.

5. Conclusions
The different dimensions of L&D of climate change make this a complex topic, with a range of interpretations, approaches and responses being considered, while the political negotiations are in full flow. Reflecting on the current state of discussion, we draw the following conclusions.

To date, there are no easy answers to the L&D challenges. This is not only due to technical and science limitations, but also due to the political dimension and the uncertainties inherent in this process. Lacking a clear definition of L&D does not help either.

L&D of climate change is a political concept, with its technical roots in CCA and DRR. Most of the components suggested under the UNFCCC work programme are well embedded in ongoing efforts within climate adaptation and DRR. As stated, there are a wide range of tools and approaches from the fields of CCA and DRR that can help responding to L&D, particularly for extreme events.

This therefore underlines the importance of holistic approaches, incorporating hazard, vulnerability and exposure elements of risk. In this context, the recognition of the importance of data for all three risk aspects is important, and there are some clear shortcomings in terms of accessibility, availability and quality of risk data for all three components.

Climate science provides the foundation for the L&D of climate change discussions. Therefore, recognition of limitations and uncertainty is important, particularly for those who will make decisions around L&D. In a similar way, limitations with regard to loss assessments and accounting for indirect consequences as well as estimating socio-economic risk drivers exist and those involved in L&D need to understand and embrace those challenges.

How we respond to these challenges and limitations depends on the specific goals and aims associated with L&D. We can identify three goals embedded in the L&D discussion:

- create awareness about the sensitivity of human and natural systems to climate, and the need to respond with appropriate mitigation, adaptation and DRR policies;
- support risk reduction and risk management, with the goal to enhance adaptation to reduce vulnerability and build resilience and
- inform compensation mechanisms.

The first two goals are common to the CCA and DRR discussions, and lessons learnt in those areas can be shared here. The lack of data and knowledge should not be seen as a reason for delaying action – in fact, there are a range of existing instruments and tools that can be applied to assess and manage current and future L&D. As previously discussed, within the CCA community, tools and approaches have recently been developed to deal with uncertainty from climate science in order to avoid a ‘wait and see’ mentality for decision-making. These can be applied to most of the L&D decision-making, in the same way as suggested for CCA. In this context, the challenges presented by the need to reduce and manage climate change L&D are not very different from the ones presented by the need to adapt to climate change and variability.

The compensation component of L&D, however, offers a different dimension to the climate change discussion. While not explicitly outlined in the official UNFCCC language, this is an underlying aim that has been driving the L&D debate since its beginnings. The focus on compensation for those climate impacts that are beyond mitigation and adaptation’s reach poses some additional challenges for decision-makers – particularly in the context of the underlying science. Approaches used to estimate the attributable part of the risk of L&D to human-induced climate change are highly debated within the science community.

On the other hand, the majority of the climate change experts (as reflected by the last chapters of IPCC, 2012) seem to have come to the conclusion that the only way to deal with climate change is to take a holistic approach to risk management. From the adaptation and DRR perspective, the causation question is less important. However, the idea of L&D for compensation could require a break with this approach and might trigger increased efforts to dissect the human-induced climate change part of the risk.

While valid political and moral reasons drive the debate around compensation, an increased focus on the complex and possibly unsolvable attribution question might put on
hold the efforts to integrate adaptation to climate change with wider development aims and DRR.

Acknowledgements
This research was supported by the LSE’s Grantham Research Institute on Climate Change and the Environment and the ESRC Centre for Climate Change Economics and Policy, funded by the Economic and Social Research Council and Munich Re.

Notes
1. Loss and damage as a concept was established at negotiations at the 13th COP in Bali in 2007, which called for consideration of ‘disaster risk reduction strategies and means to address loss and damage associated with climate change impacts in vulnerable countries’ (UNFCCC, 2008a. Para 1 (c)(iii)).
2. Others include the Climate and Development Knowledge Network, the European Capacity Building Initiative, the Third World Network and the International Centre for Climate Change and Development.
3. Detection of climate change is the process of demonstrating that climate has changed in some defined statistical sense, without providing a reason for that change. Attribution of causes of climate change is the process of establishing the most likely causes for the detected change, either natural or anthropogenic, with some defined level of confidence (source: IPCC, 2012).

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