



Loss and damage from climate change and implicit assumptions of sustainable development

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Received: 24 February 2020 / Accepted: 6 January 2021 / Published online: 23 January 2021
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Abstract

Loss and damage from climate change, recognized as a unique research and policy domain through the Warsaw International Mechanism (WIM) in 2013, has drawn increasing attention among climate scientists and policy makers. Labelled by some as the “third pillar” of the international climate regime—along with mitigation and adaptation—it has been suggested that loss and damage has the potential to catalyze important synergies with other international agendas, particularly sustainable development. However, the specific approaches to sustainable development that inform loss and damage research and how these approaches influence research outcomes and policy recommendations remain largely unexplored. We offer a systematic analysis of the assumptions of sustainable development that underpins loss and damage scholarship through a comprehensive review of peer-reviewed research on loss and damage. We demonstrate that the use of specific metrics, decision criteria, and policy prescriptions by loss and damage researchers and practitioners implies an unwitting adherence to different underlying theories of sustainable development, which in turn impact how loss and damage is conceptualized and applied. In addition to research and policy implications, our review suggests that assumptions about the aims of sustainable development determine how loss and damage is conceptualized, measured, and governed, and the human development approach currently represents the most advanced perspective on sustainable development and thus loss and damage. This review supports sustainable development as a coherent, comprehensive, and integrative framework for guiding further conceptual and empirical development of loss and damage scholarship.

Keywords Loss and damage · Climate change · Sustainable development · Capital theory · Human development

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1 Introduction

The issue of loss and damage (L&D), recognized as a unique research and policy space in addition to mitigation and adaptation through the Warsaw International Mechanism (WIM) in 2013, has drawn increasing attention at the nexus of climate change (CC) science and policy. Some have suggested that, as a “third pillar” of the international climate regime (with mitigation and adaptation), L&D has the potential to catalyze important synergies with other international agendas, particularly sustainable development (Roberts et al. 2015). For example, the Paris Agreement recognizes the role of sustainable development in reducing L&D (Sindico 2016), and there is increasing interest in policy and academic circles to connect L&D to “the values embedded in the Sustainable Development Goals” (Warner 2018). The recent review of the WIM at COP 25 in December, 2019, explicitly encourages its working group “to take into account... areas of work that may require short-, medium- and long-term consideration and efforts, including in relation to sustainable development and transformative change...” (decision point 16). In light of these ambitions, we ask: how do assumptions about sustainable development influence L&D research and policy?

In this paper, we present a systematic review of L&D scholarship with specific attention to explicit and implicit relationships between L&D and sustainable development. We analyzed 145 peer-reviewed articles to uncover the assumptions of sustainable development theory expressed in L&D research and how these theoretical positions correspond to specific metrics, decision criteria, and policy prescriptions currently recommended to L&D practitioners in the literature. We structure our review by organizing L&D research into four distinct clusters of research that highlight specific “perspectives” and theoretical linkages with sustainable development: weak sustainability, critical capital, wish list, and the human development perspective (see Boda and Faran 2018). By relating L&D research clusters to corresponding theories of sustainable development, we provide three important contributions: (1) we make explicit linkages between L&D research and sustainable development theory through analysis of L&D metrics and governance strategies; (2) we highlight the conceptual and empirical frontiers of sustainable development-related L&D research; and (3) we take major steps toward identifying a truly coherent, comprehensive, and integrative approach to L&D. This is a particularly timely contribution given the recent review of the WIM at COP 25, the outcomes of which stressed that the principles of coherence, comprehensiveness, and integration are essential to springboard the translation of L&D research into more effective policy and response mechanisms.

2 Methods and analysis: identifying corresponding theories of sustainable development in L&D research

To frame this review of L&D, we recognize that the global failure or inability to maintain a sustainable development, which includes efforts aimed at mitigating and adapting to climate change, is the underlying causal factor in the manifestation of L&D. As a result, approaches taken to avoid, minimize, or address L&D are influenced by the more general sustainable development strategies adopted which clarify *what should be sustained* when navigating trade-offs between economic development and environmental conservation (Boda et al. 2020). The main benefit of framing L&D from the perspective of sustainable development is that it provides a more comprehensive, coherent, and integrative framing of L&D than other

approaches (i.e., risk-based) by aligning the normative aims of certain development strategies with L&D concepts, metrics, and forms of governance. By concepts, we mean the core ideas that define what L&D is; by metrics, we mean the information and tools needed to measure, monitor, and evaluate a particular perspective; and by governance, we mean the practical activities aimed at either avoiding, minimizing, or addressing L&D from climate change. The most influential sustainable development perspective to date is the capital theory (with its weak and critical capital variants), while the human development perspective remains a viable but marginal alternative (Boda and Faran 2018). The capital theory perspective suggests that sustaining economic capacity to produce goods and services is achieved by maintaining a stock of productive capital as a means to meet human needs (Stern 1997). The human development perspective, in particular Amartya Sen's capabilities approach, suggests that sustaining individual and collective capacity (capabilities) will achieve valued human states of being and doing (functionings) (Sen 2001). Viewing L&D through these divergent perspectives of sustainable development should lead to very different appraisals of what L&D is, how it should be measured, and what the appropriate policies are to effectively address it when it occurs.

We searched Web of Science (December, 2019) using the broad search strings "loss and damage" AND "climate change". This produced a 137-paper sample before manual refinement. We reviewed the resulting article titles and abstracts manually, highlighting papers with only ambiguous connections to the search topic—all papers with obvious or strong connections were included in the final literature sample. In this process, we flagged 30 papers for further review to determine inclusion. After reviewing the full papers, two of the 30 flagged papers were removed for lack of relevance. Eight additional papers were found through analysis of citations in articles reviewed. This resulted in a final article sample size after manual refinement of 145 peer-reviewed articles.

Our initial approach was to categorize L&D research according to theories of sustainable development explicitly used in each L&D paper; however, this proved impossible due to the lack of explicit engagement between these bodies of literature. Of the 145 articles reviewed, we found that 66% makes no mention of sustainable development in any way, no matter how banal. The remaining 34% which does mention sustainable development either mentions it generically or refers specifically to the SDGs as a related policy initiative; no articles reviewed explicitly employed a definition or theory of SD. We instead attempted to identify the implicit sustainable development theory through analysis of each paper's definition of L&D. If anything is agreed upon in L&D research, however, it is that there is currently no agreed upon definition. We are confronted with a variety of different definitions in the 145 articles reviewed, with a handful of (intentionally) vague definitions most commonly employed (see definitions breakdown Fig. 2 in supplementary materials). The lack of conceptual clarity in these multiple definitions has created confusion that some argue has prevented L&D research from advancing theoretically, while also stalling the development of comprehensive, effective policies for addressing L&D in practice (Preston 2017; Surminski and Eldridge 2015; Gall 2015; Dilley and Grasso 2016; Roberts et al. 2017). This is again one of the primary motivations for our desire to understand L&D in terms of sustainable development; sustainable development provides an overarching framework for coherently conceptualizing, measuring, and ultimately addressing L&D.

Due to this definitional ambiguity, we could not directly relate each article's definition of L&D to sustainable development theories. Instead, we had to first surface implicit

understandings of L&D by analyzing metrics, policy strategies, and concepts embedded and explicitly supported in each article. After reconstructing an article's conception of L&D in this manner, we were able to relate it to a corresponding sustainable development perspective. We do so in reference to a typology of sustainable development (see Boda and Faran 2018). While there are many ways to classify approaches to sustainable development (e.g., Hopwood et al. 2005), a typology is different from such common classifications in that it is not merely descriptive but claims that the organizing principle of the types (i.e., what is to be sustained) has an explanatory power. That is to say, the organization of the typology explains different features of each type in a consistent manner. A typology of sustainable development should provide some criteria for judging the consistency between aims—declared or tacit—of sustainable development, the relevant concepts, metrics, and tools within each type.

In relation to this final process, a further 21 articles were deemed not relevant to capturing theories of sustainable development in L&D (e.g., technical descriptions of climate change attribution methodologies). In the final analysis, we fully reviewed and analyzed 124 papers.

3 Results and discussion: concepts, metrics, and governance of L&D from four sustainable development perspectives

Our detailed review of 124 peer-reviewed articles reveals four distinct clusters of L&D research that we differentiated in terms of their underlying sustainable development perspective (Fig. 1). The first cluster we describe herein represents the most prominent sustainable development perspective present in the L&D research, that of economically focused “Weak Sustainability” (40% of articles). We use the label “Weak Sustainability” due to its prominent use in the sustainable development literature (see Stern 1997); it does not imply a “weak” judgment on behalf of the authors. The second cluster we analyze is the smallest, which represents an environmentally focused revision to the first cluster, namely “Critical Capital Sustainability” (5% of articles). This is followed by the third cluster, which we label the “Wish List” of valid concerns (31% of articles). The fourth and final cluster posits sustainable development and thus L&D in the tradition of human development (HD; 7% of articles). The inclusion of an article in a research cluster does not imply the explicit adherence of the article's authors to the referenced sustainable development perspective; rather, we argue that these authors *de facto* adopt certain theories of sustainable development via their understanding of L&D (see Methods and Analysis).

The number of the SDG goals most relevant to each cluster is highlighted as an indication of the breadth of concerns within each approach. The bottom axes represent an increasing (from left to right) concern for the most vulnerable groups in society. The number within and the size of the gray circles are proportionate to the clusters percentage of total articles analyzed. The graphic does not include the ethics and justice cluster; thus, the percentages do not sum to 100%.

The sustainable development perspective correlated with each of the four clusters of L&D research reviewed exist along gradients of comprehensiveness of their considerations (from economic, to environmental, to societal concerns), as well as an increasing recognition of disproportionate impacts and social vulnerability to climate change. Below we review and distinguish each cluster by its conceptual content, focus on metrics or measurement, and governance implications, derived from the underlying sustainable development assumptions implicitly informing each approach to L&D.

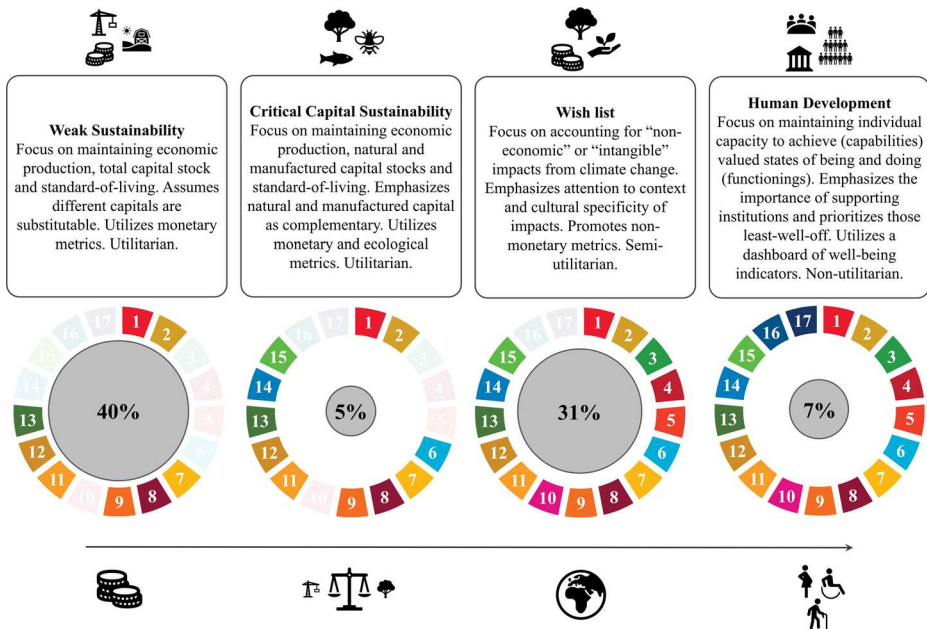


Fig. 1 Each box contains a brief description of the defining characteristic of the clusters of L&D research

We also identified a fifth cluster of L&D research pertaining to ethics and justice, and accounting for 16% of all articles reviewed. The angle of justice is central to L&D, and we are aware that there are several distinct theories of justice in moral philosophy, and as a result, different perspectives on justice in the L&D literature are in need of being reviewed in the context of sustainable development. We emphasize that the question of ethics and justice in L&D research is critical, so much so that it deserves a close treatment in its own right. This treatment can build on an initial clarification of the assumed theories of sustainable development in L&D research that we propose here. Recognizing the centrality of this issue, we set it aside for now with the intention to give it a proper treatment in future research, once we have explored the sustainable development theories underlying L&D research, our aim at present.

3.1 Weak sustainability perspective on L&D

3.1.1 Concepts

The weak sustainability perspective represented in cluster 1 is the base version of capital theory, where the primary aim of sustainable development is to maintain (or grow) generalized capacity to produce economic well-being. Here, major impacts from climate extremes are viewed as a concern because they disrupt production processes by depleting some capital, thus reducing the productive capacity of society, and as a result lower the ability to meet individual and collective needs (Lyster 2015; Lashley and Warner 2015; Lassa et al. 2016; Kemp-Benedict et al. 2019). Addressing L&D through the weak sustainability perspective is fundamentally about retrieving (at least) the initial level of capital stock, thus resuming the level of production that existed before the experience of, e.g., an extreme event. Similarly, preventing L&D in this perspective prioritizes protecting the existing level of production by making sure

that the existing capital stock is not vulnerable to (impending or hypothetical) impacts from CC (He et al. 2015). The focus on capital stock has been termed by some as prioritizing “protecting development investments” (Surminski and Eldridge 2015; Benjamin et al. 2018).

Weak sustainability requires that L&D be understood in terms of impact on specific productive capital assets. This includes, for example, direct impacts on agricultural fields, livestock, critical infrastructure, and lost labor, as well as loss of yield/revenue from, for example, crop losses (e.g., cereals, rice, rubber, acacia) and money spent on recovery/coping/adaptation. This literature covers such impacts across a variety of sectors, most predominantly agriculture, but also, e.g., tourism (Forzieri et al. 2018; Lassa et al. 2016; Tiepolo et al. 2018; Brown et al. 2018; Beckman and My Van Thi 2016; Huggel et al. 2015). There is also recognition that productive sectors can be interlinked, with CC impacts triggering “chain losses down the line of connected [production] systems” (Zaidi 2018). This also implies that L&D to capital stocks may be “direct, indirect, or secondary/consequential” (Wirtz et al. 2014).

3.1.2 Metrics

Measurement of observed and projected L&D requires calculating the value of impacts to capital assets by actual or potential warming trends. For example, there have been studies on projected impacts to productive capacity in Europe, SIDS, and at the global level (respectively) (Forzieri et al. 2018; Hinkel et al. 2014; Thomas and Benjamin 2018a; Marjanac and Patton 2018) and studies on observed impacts in Caribbean, China, SIDS, Fiji, Australia, Colombia, and Alaska (Lashley and Warner 2015; He et al. 2015; Benjamin et al. 2018; Brown et al. 2018; Huggel et al. 2015; Frieler et al. 2017; Sultan et al. 2019). At the most aggregate level, L&D to productive capacity is measured in terms of GDP, which also can be either in terms of measured losses to (Benjamin et al. 2018) or projected impact on (Hinkel et al. 2014; Pretis et al. 2018; Gsottbauer et al. 2018) a nation’s total capital stock.

This research highlights the centrality of monetary metrics and the reliance on economic choice and cost-benefit analysis in deciding how to handle L&D. Since different forms of capital are assumed to be substitutable with each other within weak sustainability, exchange value is utilized as a general equivalent between various kinds of capital, and addressing L&D focuses on the “replacement value” of lost or damaged capital (Lassa et al. 2016; Brown et al. 2018; Zaidi 2018; Mace and Verheyen 2016). Much of the empirical literature in this cluster draws on existing damage databases to calculate L&D (e.g., NatCatService, Desinventar, EM-DAT) (Tiepolo et al. 2018; Doktycz and Abkowitz 2019). The standard criteria in these databases include number of people affected, number of people killed, and monetary damages accrued to infrastructure, property, and other assets (Wirtz et al. 2014).

Some have pointed out the difficulty in monetizing some aspects of L&D, for example, capital stocks that are not commonly traded on markets (Thomas and Benjamin 2018a). From the perspective of weak sustainability, the point is not to wonder about the difference between “economic” and “non-economic” L&D, but if the purpose is compensation, the point really is how to turn so-called “non-economic” L&D into monetary quantification (Mintz-Woo 2018). Research in this cluster often recognizes that capital stocks without a price can be valued using standard methods (e.g., lost productivity, ecosystem valuation, econometric models, general equilibrium models, ECLAC methodology) (Gall 2015; Dilley and Grasso 2016), as has also been acknowledged by the UNFCCC (Preston 2017).

3.1.3 Governance

The use of monetary metrics for measurement and compensation points to the assumption of substitutability of capitals, with important implications for L&D. Although directly compensating lost capital by paying out its monetary value is of course an option and often what comes to mind when “compensation” is discussed (Mayer 2014), the logic of weak sustainability would suggest that whatever the most efficient way to replenish the total stock of capital to the former level (rather than replacing the *same* capital) is the appropriate course of action. This can be in the form of, for example, changing the type of productive activity by remaining “flexible”, including adjusting crop type or changing jobs (e.g., from farming to day labor) (Ahmed and Schmitz 2015; Beckman and My Van Thi 2016). It can also take the form of investing in other factors that improve productivity, e.g., knowledge and capacity building (Roberts et al. 2017), as long as doing so maximizes social utility.

Regarding practical tools, this perspective utilizes economic reasoning and cost-benefit analysis (Lincke and Hinkel 2018) to justify investing in projects to avoid or minimize L&D. The L&D that is beyond CBA justification has been labeled as “residual” (Ma et al. 2015). Managing financial vulnerability leads to the use of economic risk management tools (Mechler and Schinko 2016; Schinko and Mechler 2017), including various forms of insurance, disaster bonds, and disaster hedging (Burkett 2014; Wirtz et al. 2014; Broberg 2019; Nordlander et al. 2019). These tools facilitate the management of financial risks to reduce loss of capital (Hochrainer-Stigler et al. 2017). They also facilitate capital investment and substitution post-disaster (Lyster 2015; Hochrainer-Stigler et al. 2017; Kehinde 2014; Emmerling 2018; Mayer 2014), even in situations where avoiding L&D may not “comply with cost-benefit principle” (Ma et al. 2015; Sharma 2017). The private sector sees these as posing “business opportunities” in the areas of “insurance, modelling, reconstruction” (Surminski and Eldridge 2015).

One reason for the prevalence of the weak sustainability perspective may be its inherent reductionism. Having one-dimensional metrics (i.e., assuming all values are commensurate) simplifies evaluation and makes policy choice more decisive (Porter 1996). The literature in cluster 1 echoes this need for a universal approach, arguing that it is essential for L&D to be consistently addressed (Roberts et al. 2017) and practically necessary due to limitations of existing data, which is largely monetary (Gall 2015; Dilley and Grasso 2016). Furthermore, Surminski and Eldridge (2015, p. 13) note that the lack of a clear definition “can create confusion amongst stakeholders such as the private sector”. This confusion is considered problematic because misunderstanding actual monetary values may “encourage over-investment in preventative measures and/or under-invest in productive activities” (Brown et al. 2018).

3.2 Critical capital sustainability perspective on L&D

3.2.1 Concepts

The “Critical Capital sustainability” perspective represented in cluster 2 emphasizes the unique role of natural capital in maintaining production. Some research in cluster 1 already notes that CC will impact natural systems in a way that will affect humans (Ourbak and Magnan 2018; Vincent and Cull 2014; Hoard 2016; Birkmann and Welle 2015; van der Geest 2018). Indeed, the UNFCCC working definition of L&D “explicitly includes losses and damages that negatively affect natural systems” (McShane 2017). However, what distinguished cluster 2

is the explicit recognition of the importance of specific kinds of natural capital in specific production sectors and for specific communities, such as agriculture and tourism (Stabinsky and Hoffmaister 2015), as well as forestry and marine subsistence systems (Sonja and Harald 2018). The main argument is that there is a critical level of (particular) natural capital that has to be maintained or the aggregate stock of capital would be diminished (see Blicharska et al. 2019). As a result, the main concern with CC is that L&D may undermine major natural systems which underpin economic production, e.g., “land use patterns, cropping systems, productivity, and optimum agriculture output [which will] adversely affect the livelihoods, economic activities and environments” (Arfanuzzaman et al. 2016). This comes with emphasizing the need to explicitly account for all ecosystem services whenever a productive natural habitat is impacted by CC (Cabral et al. 2017).

Here, there is also some initial recognition of L&D to natural capital as non-substitutable, which is discussed as “irreversible” damage to natural resources that cannot be replaced, repaired, or restored, e.g., freshwater resource loss from melting cryosphere (Stabinsky and Hoffmaister 2015; Huggel et al. 2019), which differentiates this perspective from the substitutability assumptions in cluster 1. Cluster 2 is the first place where ecological science would have an explicit role in measuring and addressing L&D. However, while distinct from cluster 1 in its rejection of substitutability assumptions and focus on critical natural capital, the primary focus is still on the stock of capital as the determinant of economic growth, thus remaining within capital theory more broadly. This is opposed to the perspectives that, say, recognize institutions, or well-defined property rights, or perfect markets, as determinants of growth, as we will see below.

3.2.2 Metrics

The critical capital sustainability perspective requires employing a combination of environmental and monetary metrics to monitor changes in critical productive capital stocks. Although not yet used in relation to L&D, in other contexts, ecologists have argued that researchers can apply ecological principles and modeling tools to identify and monitor critical natural capital (Brand 2009). There is already recognition within the weak sustainability literature of cluster 1 that there is a need for improved indicators related to L&D of natural capital in current disaster databases, the inclusion of which is currently “patchy and arbitrary in scope” if not “entirely missing from the indicator set” (Zaidi 2018). While currently underutilized, there are however promising candidates for indicators of ecological sustainability, for example, the numerous environmental indicators underpinning ecological SDGs (e.g., indicator sets 14 and 15). As noted in cluster 1, it is possible to monetize critical natural capital that does not currently have a market price, using a variety of standard methods, though different approaches can lead to quite different values (TEEB 2010).

3.2.3 Governance

The policy implications of cluster 2 are geared toward environmental conservation and sustainable management. Some researchers argue, for example, that the importance of natural capital for maintaining productive capacity suggests the need to support “ecosystem based adaptations” (Arfanuzzaman et al. 2016) which ensure addressing L&D is accomplished within “planetary boundary” constraints (Preston et al. 2013; Sharife and Bond 2013). This implies the need to address “ecological debt” through conservation and restoration and

promote policies that address L&D in a way that uses natural capital while also protecting and conserving it (Sharife and Bond 2013). In this regard, the need to preserve critical natural capital may require interventionist political decisions (Sharife and Bond 2013). Recent work by Bruckner (2019) suggests that other international policy frameworks, in particular the Global Pact for the Environment, could help in connecting L&D policy and practice to concerns over the conservation of environmental assets.

3.3 Wish list perspective on L&D

3.3.1 Concepts

The third cluster, which represents a wish list of valid concerns, in addition to economic issues has a strong emphasis on so-called “non-economic” forms of L&D that have not been well-captured by the previous clusters. This includes losses to culture, health (mental and physical), territory, social networks and relationships, and even “epistemic” loss (Taub et al. 2016; Preston 2017; Warner and van der Geest 2013; Werkheiser 2017; Scott and Smith 2017; Acosta et al. 2016; Bauer 2013; Monnereau and Abraham 2013), issues which have also been noted by the UNFCCC more generally (Serdeczny et al. 2018). These forms of L&D are often discussed as “intangible” due to their deriving from culture and identity (Chandra et al. 2017; Tschakert et al. 2019; Tschakert et al. 2017; Fekete and Sakdapolrak 2014). Such “intangible” L&D may also include ecosystems, but less for their contribution to production (cf. cluster 2 above) than their cultural, ethical, or other immaterial significance (Preston 2017; Barnett et al. 2016; Mukherji et al. 2019). Overall, this cluster represents a broader range of L&D than is currently being explored by most L&D scholars (McShane 2017; Birkmann and Welle 2015; Gewirtzman et al. 2018). Many of these kinds of impacts are related to climate-induced migration (Mayer 2017; McNamara et al. 2018; Roberts and Pelling 2018; Roberts and Andrei 2015; Thomas and Benjamin 2018b; Thomas and Benjamin, 2019).

Many of these forms of “non-economic” and “intangible” L&D are considered to be irreplaceable, not necessarily due to their being complementary to other forms of capital (cf. cluster 2), but due to their deriving from place and cultural specificity (Taub et al. 2016; Tschakert et al. 2019; McNamara et al. 2018; Thomas and Benjamin 2018b; Barnett et al. 2016). Such L&D is recognized as differential because of context-specific physical characteristics like geography, as well as culture, age and gender of the impacted population, as demonstrated in case studies in the Philippines, Bangladesh, Nepal, the Hindu Kush Himalaya, and Gambia (Chandra et al. 2017; Rabbani et al. 2013; van der Geest and Schindler 2016; Eugenio et al. 2016; Yaffa 2013; Mukherji et al. 2019). Some of this literature discusses more concretely why and how these impacts matter to people and thus constitute L&D. There are two main lines of argument. First, some researchers emphasize that L&D needs to be understood in terms of the values people hold (Tschakert et al. 2019; Tschakert et al. 2017; Barnett et al. 2016). Second, some researchers emphasize concerns over maintaining human agency (Warner 2012), including the importance of maintaining access to basic goods (Herington, 2017). While some discuss agency in terms of “self-determination” (e.g., knowledge and practice, participation) (Werkheiser 2017; Tschakert et al. 2019; Roberts and Andrei 2015), the concept of “agency” can be equivocal, as it could easily be reducible to “human capital” and thus incorporated into capital theory, as opposed to agency as “self-determination” which is quite different.

It is important to note that simply pointing beyond capital stock does not necessarily imply moving beyond economic reasoning or a focus on utility maximization. Concerns over “cultural” or “social” L&D could well reflect a strong advocacy of economic growth, for example, when such factors are seen as important in lowering transaction costs (see, e.g., Putnam 2001). This would, for example, bring into focus the role of trust institutions (Birkmann and Welle 2015) and cultural heritage (Vincent and Cull 2014) in ensuring smoothly operating economic activity. Such a perspective is different from capital theory in that instead of stock of capital, it recognizes a smoothly operating market (which technically translates into a market with low transaction costs) as the decisive determinant of growth.

3.3.2 Metrics

Some of the authors in this cluster seem to reject the use of (primarily) monetary metrics, calling for a richer informational basis to be considered in L&D research (McShane 2017), which could be achieved through e.g. increased participation. Although some recommend moving beyond economic dimensions of L&D, they often do so only formalistically. We say this because many of the emphasized “intangible” and “non-economic” dimensions of L&D included in this cluster can reasonably be reduced to economic categories and thus be incorporated in capital theory, e.g., health (physical and mental) as “human capital”, as previously mentioned.

However, some authors in this cluster stand out by explicitly arguing that quantitative, particularly monetary, approaches exclude important, qualitative considerations which they argue either cannot (Verchick 2018; Roberts and Andrei 2015) or should not be quantified (Tschakert et al. 2019; Serdeczny et al. 2018). More specifically, some argue that monetary metrics and related tools (e.g., IAMs) miss the multi-dimensional nature of L&D which can have disproportionate implications for the most vulnerable social groups (van der Geest and Schindler 2016). Some suggest instead that focus should be on ensuring “sustainable livelihoods” rather than focusing on the monetary equivalent, with the recognition that the utility derived from a certain level of income can be very heterogeneous across social groups and individuals (e.g., an enabled person versus a person with disabilities) (van der Geest 2018). This literature points to going beyond the utilitarianism of monetary metrics, which distinguishes it from primarily economic approaches to L&D. As an alternative to monetary metrics, some authors point to existing well-being frameworks for appropriate indicators, e.g., those developed under the human development approach to well-being (Verchick 2018; Serdeczny et al. 2018; Preston 2017) (discussed more in the next section), though these alternative indicators are not actively utilized within this cluster of research.

3.3.3 Governance

What policy recommendations may eventually flow from the wish list cluster is inconclusive. However, there is a general consensus that what counts as “appropriate” policies needs to be “adapted to the local needs and values of local communities” (Acosta et al. 2016). Furthermore, it is argued that this requires a participatory, “co-production” approach to develop policies that are situated in specific socio-cultural contexts (Barnett et al. 2016). However, an unconditional support of “community” and especially “cultural preservation” could be problematic. While what is considered important L&D may depend on the “values” of a certain community, and what kind of culture they have, it is clear that some “community values” may

very well be oppressive to particular social groups, not least women and girls (Sen 1989). How to handle this tension, and by what decision procedure certain values would be prioritized, is not addressed in this wish list cluster.

3.4 Human development perspective on L&D

3.4.1 Concepts

The fourth cluster of research identified, which represents a capabilities approach to human development, in many ways builds on a recognition of the other perspectives covered so far, including the importance of productive capacity, environmental assets, and place-specific social relations and cultural traits. However, the major difference between this cluster and those previously considered is related to the explicit claim that these aspects are important because of their implications for whether individuals can achieve valued states of living (Wrathall et al. 2015; Gendreau 2017). As such, the main focus of the human development perspective to L&D is on the substantive freedoms people have to achieve a certain level of well-being (as opposed to standard of living) (Lyster 2017). Valued states of being and doing are seen as a function of a person's capabilities set, or the substantive opportunities available to the person (e.g., their ability to live long and healthy lives, benefit from educational opportunities, participate politically, etc.). The utilizing of different parts of a person's capabilities set produces various functioning states. L&D from climate-related extreme events can negatively (or positively) influence whether a person can, still can, or can no longer utilize their full capability set and thus actually achieve desired states of being and doing (functionings) (Schwan and Yu 2018), as demonstrated in case studies in Bangladesh and Japan (Chiba et al. 2017). Furthermore, as opposed to the capital theory perspectives, the human development perspective is pluralist about value in the sense that the kinds of capabilities relevant to L&D differ in quality, not just quantity (Chiba et al. 2017; Lyster 2017). An important component of individual capabilities is the necessity of supporting social institutions that provide a context within which individuals can substantively utilize their capabilities (Lyster, 2017; Chiba et al. 2018).

This cluster places strong emphasis on the most vulnerable individuals and communities as the priority for action regarding L&D. This is because improving the capabilities of the least-well-off is seen as both the ends of sustainable development (the expansion of capabilities) and the means to further sustainable development (improving one's capabilities set allows them to more effectively participate in the further expansion of the capabilities of themselves and others) (Lyster 2017).

3.4.2 Metrics

The focus on capabilities necessitates a wider informational basis than that considered under the weak and critical capital perspectives above. Instead, a dashboard of indicators related to various relevant capabilities would be needed, for example, those linked to the measurement of well-being noted by some researchers in cluster three above (Verchick 2018; Serdeczny et al. 2018; Preston 2017). While the explicit measurement of the impacts of CC on capabilities has not yet been advanced in L&D research, examples of how this may be done exist in other development contexts. Capabilities can be objectively and subjectively measured in various ways, utilizing many standard techniques and existing data sources to develop a relevant

dashboard of well-being indicators, though improvement in the availability and quality of indicator data for at least some capabilities is likely to be necessary (Stiglitz et al. 2010). Outside of L&D, there is some debate over whether human development should come with a standard list of basic capabilities (Nussbaum 2003), or be left open for context specificity (Sen 2004). Within the scope of L&D, and recognizing the heterogeneity in socio-economic conditions and cultural value systems, the preference would perhaps be to avoid fixed lists of indicators, instead going for a dashboard of indicators fit for context (Lyster 2017).

3.4.3 Governance

The focus on the individual's ability to achieve valued states of being implies that, apart from monetary compensation, major focus of L&D policies would need to be on (re-)establishing the conditions conducive to certain functioning states, or which actively expand the range of substantive capabilities. In other words, the aim of L&D policy, as Gendreau (2017, p. 169) put it, should be "promoting those contexts within which particular forms of agency and value expression can flourish". Examples in the literature on how governance of L&D can be addressed in a way that prioritizes capabilities include mobilizing more mental health services, increased attention to malnutrition, and ensuring educational opportunities for children, among others (Chiba et al. 2018). This emphasis on well-being is in line with what some researchers capture under the rubric of "social protection" (Schwan and Yu 2018; Aleksandrova 2019). Furthermore, some research within this cluster recognizes that simply putting things back the way they were prior to the experience of L&D is insufficient, as it fails to address pre-existing inequalities (Wrathall et al. 2015; Roberts and Pelling 2019). Indeed, one of the purported strengths of taking a capabilities approach to impact studies is its ability to disaggregate impacts and bring to light pre-existing social inequalities (Gardoni and Murphy 2009). When prioritizing capabilities and focusing on addressing the needs of the least well off, the importance of conducive social institutions cannot be overstated, and their existence should not be assumed. Implementing a capabilities approach in the face of existing social inequalities is one of the major theoretical and practical challenges of this approach.

The question of which capabilities should be prioritized will surely arise. While not discussed in the L&D literature, the "social choice" approach to collective decision-making has been suggested by Amartya Sen himself as the appropriate procedure associated with a capabilities approach to sustainable development (Sen 1999), and the same would apply to L&D. Social choice is the process by which the dashboard of indicators are ranked by priority through social negotiation, which then provides the criteria for assessing competing projects relating to L&D. Importantly, as pointed out by Gendreau (2017), this does not imply that "every interest must be met". Rather, the general orientation in decision-making is toward the expansion of capabilities, particularly for the least-well-off.

4 Research and policy implications

Our review of the theories of sustainable development implicit in L&D research has important implications for both future research and policy. The four research clusters reviewed here reveal that there are multiple theories of sustainable development at work in L&D research, each with their own strengths and limitations, and further research is needed to better understand the contribution of each sustainable development perspective in defining and

addressing L&D in policy and practice. The particular strengths, weaknesses, and research frontiers of each cluster are summarized in Box 1.

Box 1. Strengths weaknesses and research frontiers of four L&D research clusters reviewed.

Cluster 1: The strengths of the *Weak Sustainability* perspective on L&D are its universality and scalability, clear policy relevance and ability to utilize data and tools already well developed in the areas of DRR and CCA. This perspective has important limitations in particular related to the accuracy and legitimacy of the valuation techniques utilized as means to incorporate non-market concerns into decision-making processes (i.e. CBA). As a result we see the frontier of this research cluster to be in developing and testing improved valuation processes which improve the accuracy and social acceptability of the monetary measurement of all forms of L&D, for example connecting to promising work on “deliberative” approaches to monetary valuation (Bartkowski and Lienhoop 2018).

Cluster 2: Among the strengths of the *Critical Capital Sustainability* perspective on L&D is the explicit focus it brings to ecological limits and ecosystem conservation which has been acknowledged in sustainability-related research and policy circles for some time (Kates et al. 2005). However significant limits remain in particular around techniques for adequately identifying and monitoring critical natural capital stocks in practice. As a result we see the frontier of this research cluster to be in the extremely underdeveloped area of how to apply well-established knowledge of ecosystem change and conservation to the measurement and evaluation of L&D and how to translate this into scalable policy prescriptions that reflect the best practices of conservation science.

Cluster 3: Among the strengths of the *Wish List of valid concerns* perspective on L&D is the breadth of relevant considerations it identifies beyond economic production specifically, and the related insistence on the theoretical and practical importance of paying acute attention to context which also draws attention to the most-vulnerable populations. The major limits in this cluster are however significant, related in particular to the lack of theoretical coherence among the diverse concerns, which is also reflected in the ambiguity of its policy implications. As a result we see the frontier of this research cluster to be in making conceptual advances capable of consistently and coherently handling these many concerns which will help make them more amenable to measurement, monitoring and scalable policy prescriptions.

Cluster 4: The strengths of the *Human Development* perspective on L&D are many. These include its ability to account for and incorporate a wide variety of heterogeneous information, its ability to remain context sensitive while also scalable, its instrumental and substantive focus on the most vulnerable groups in society and its emphasis on the disaggregation of impacts. While this perspective is theoretically strong it currently suffers from important limitations regarding its meaningful operationalization. As a result we see the frontier of this research cluster to be in how to operationalize the capabilities perspective across a diversity of contexts and scales, including what social institutional arrangements are conducive or prohibitive to its uptake as a decision-making logic. This latter aspect is particularly important regarding the utilization of a social choice procedure for ranking relevant capabilities for decision-making purposes, which will be necessary for this perspective to be effectively utilized as a L&D policy.

Clearly, much more research is needed in the area of L&D, not only at the frontiers of each of the identified research clusters but also in evaluating these perspectives theoretically and empirically. This work will help build a more comprehensive understanding of the theoretical and practical limitations of each perspective and thus identify principles for best practice and robust L&D policy development and implementation. Doing so will also inform practitioners about the assumptions embedded in, and practical implications of, their adoption of certain strategies of sustainable development in service of avoiding, minimizing and addressing L&D.

In terms of L&D policy, our findings suggest that practitioners should aim to clarify to which perspective on sustainable development they subscribe and justify metric and policy choices in relation to this guiding strategy. Clarifying how sustainable development assumptions are informing L&D research and suggestions for governance provides a major step toward fulfilling the ambition of the WIM to handle L&D in coherent, comprehensive, and integrative ways. This is an extremely timely contribution. Since the adoption of WIM, L&D has gained further legitimacy through its inclusion in Article 8 (2015), as well as the [transparency framework](#) and global stocktake (2018), of the Paris Agreement. However, the recent review of WIM at COP 25 concluded that there is an urgent need for translating the best available science on L&D into effective policy, including explicit compensation

mechanism(s). Our analysis demonstrates that there has been progress in L&D scholarship reflected in the continuing expansion of the boundaries of concern considered relevant to the field, with the human development perspective more than any other able to account for the wide-ranging concerns captured by the developing concept of L&D.

5 Conclusion

The results of this review support the idea that sustainable development provides a coherent, comprehensive, and integrative framework for the further development of L&D scholarship. To substantiate this, we highlight two overarching conclusions: (1) assumptions about the aims of sustainable development do in fact determine how one conceptualizes, measures, and governs L&D from CC and thus is a critical factor in L&D policy development and (2) that the human development approach currently represents the most advanced perspective on sustainable development and thus should more explicitly inform the development and implementation of L&D policy.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s10584-021-02970-z>.

Funding Open Access funding provided by Lund University. Swedish Research Council FORMAS (Beslutnr: FR-2018/0010)

Data availability A full list of analyzed articles is available upon request from the corresponding author.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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References

- Acosta LA, Eugenio EA, Macandog PBM, Magcale-Macandog DB, Lin EKH, Abucay ER, Cura AL, Primavera MG (2016) Loss and damage from typhoon-induced floods and landslides in the Philippines: community perceptions on climate impacts and adaptation options. *International Journal of Global Warming* 9:33–65
- Ahmed MN, Schmitz PM (2015) Climate change impacts and the value of adaptation - can crop adjustments help farmers in Pakistan? *International Journal of Global Warming* 8:231–257
- Aleksandrova M., 2019. Principles and considerations for mainstreaming climate change risk into national social protection frameworks in developing countries. *Climate and Development*
- Arfanuzzaman, M., Mamnun, N., Islam, M. S., Dilshad, T. & Abu Syed, M. 2016. Evaluation of adaptation practices in the agriculture sector of bangladesh: an ecosystem based assessment *Climate*, 4
- Barnett J, Tschakert P, Head L, Adger WN (2016) A science of loss. *Nat Clim Chang* 6:976

- Bartkowski B, Lienhoop N (2018) Beyond rationality, towards reasonableness: enriching the theoretical foundation of deliberative monetary valuation. *Ecol Econ* 143:97–104
- Bauer K (2013) Are preventive and coping measures enough to avoid loss and damage from flooding in Udayapur district, Nepal? *International Journal of Global Warming* 5:433–451
- Beckman M, My Van Thi N (2016) Upland development, climate-related risk and institutional conditions for adaptation in Vietnam. *Clim Dev* 8:413–422
- Benjamin L, Thomas A, Haynes R (2018) An ‘Islands’ COP? Loss and damage at COP23. *Review of European Comparative & International Environmental Law* 27:332–340
- Birkmann J, Welle T (2015) Assessing the risk of loss and damage: exposure, vulnerability and risk to climate-related hazards for different country classifications. *International Journal of Global Warming* 8:191–212
- Blicharska M, Smithers RJ, Mikusiński G, Rönnbäck P, Harrison PA, Nilsson M, Sutherland WJ (2019) Biodiversity’s contributions to sustainable development. *Nature Sustainability*:1–11
- Boda C, Faran T (2018) Paradigm found? Immanent critique to tackle Interdisciplinarity and normativity in science for sustainable development. *Sustainability* 10:3805
- Boda CS, Scown M, Faran T, Nastar M, Dorkenoo K, Chaffin Brian C, Boyd E (2020) Framing loss and damage from climate change as the failure of sustainable development. *Clim Dev*. <https://doi.org/10.1080/17565529.2020.1851640>
- Brand F (2009) Critical natural capital revisited: ecological resilience and sustainable development. *Ecol Econ* 68:605–612
- Broberg M (2019) Parametric loss and damage insurance schemes as a means to enhance climate change resilience in developing countries. *Clim Pol*
- Brown P, Daigneault AJ, Tjernstrom E, Zou W (2018) Natural disasters, social protection, and risk perceptions. *World Dev* 104:310–325
- Bruckner A (2019) The global pact for the environment: implications for climate change loss and damage. *Environmental and Planning Law Journal* 36:642–657
- Burkett MJCL (2014) Loss and damage. *Climate Law* 4:119–130
- Cabral P, Augusto G, Akande A, Costa A, Amade N, Niquisse S, Atumane A, Cuna A, Kazemi K, Mlucasce R, Santha R (2017) Assessing Mozambique’s exposure to coastal climate hazards and erosion. *International Journal of Disaster Risk Reduction* 23:45–52
- Chandra A, McNamara KE, Dargusch P, Caspe AM, Dalabajan D (2017) Gendered vulnerabilities of smallholder farmers to climate change in conflict-prone areas: a case study from Mindanao, Philippines. *J Rural Stud* 50: 45–59
- Chiba Y, Prabhakar S, Islam MA, Akber MA (2018) Priority practices for addressing non-economic loss and damages caused by cyclones in Bangladesh case study of Koyra. *International Journal of Disaster Resilience in the Built Environment* 9:333–347
- Chiba Y, Shaw R, Prabhakar S (2017) Climate change-related non-economic loss and damage in Bangladesh and Japan. *International Journal of Climate Change Strategies and Management* 9:166–183
- Dilley M, Grasso VF (2016) Disaster reduction, loss and damage data, and the post-2015 international policy agenda. *Environ Sci Pol* 61:74–76
- Doktycz C, Abkowitz M (2019) Loss and damage estimation for extreme weather events: state of the practice. *Sustainability* 11
- Emmerling J (2018) Sharing of climate risks across world regions. *Climate Change Economics* 9
- Eugenio EA, Acosta LA, Magcale-Macandog DB, Macandog PBM, Lin EK-H, Eugenio JMA, Manuta JB (2016) Adaptive capacity of Philippine communities vulnerable to flash floods and landslides: assessing loss and damage from typhoon Bopha in eastern Mindanao. *Int J Sustain Dev* 19:279–314
- Fekete A, Sakdapolrak P (2014) Loss and damage as an alternative to resilience and vulnerability ? Preliminary reflections on an emerging climate change adaptation discourse. *International Journal of Disaster Risk Science* 5:88–93
- Forzieri G, Bianchi A, e Silva FB, Marin Herrera MA, Leblois A, Lavalley C, Aerts JCJH, Feyen L (2018) Escalating impacts of climate extremes on critical infrastructures in Europe. *Global Environmental Change-Human and Policy Dimensions* 48:97–107
- Frieler K, Schauburger B, Ameth A, Balkovic J, Chrysanthacopoulos J, Deryng D, Elliott J, Folberth C, Khabarov N, Mueller C, Olin S, Pugh TAM, Schaphoff S, Schewe J, Schmid E, Warszawski L, Levermann A (2017) Understanding the weather signal in national crop-yield variability. *Earths Future* 5: 605–616
- Gall M (2015) The suitability of disaster loss databases to measure loss and damage from climate change. *International Journal of Global Warming* 8:170–190
- Gardoni P, Murphy C (2009) Capabilities-based approach to measuring the societal impacts of natural and man-made hazards in risk analysis. *Natural Hazards Review* 10:29–37

- Gendreau MS (2017) Mitigating loss for persons displaced by climate change through the framework of the Warsaw mechanism. *Ethics, Policy & Environment* 20:168–183
- Gewirtzman J, Natson S, Richards JA, Hoffmeister V, Durand A, Weikmans R, Huq S, Roberts JT (2018) Financing loss and damage: reviewing options under the Warsaw international mechanism. *Clim Pol* 18: 1076–1086
- Gsottbauer E, Gampfer R, Bernold E, Delas A-M (2018) Broadening the scope of loss and damage to legal liability: an experiment. *Clim Pol* 18:600–611
- He X, Zhang X, Ma X, Li Y, Wang W (2015) International mechanism for loss and damage from climate change: recommendations for related work in China. *Chinese Journal of Population Resources and Environment* 13: 291–296
- Herington J (2017) Climate-related insecurity, loss and damage. *Ethics Policy & Environment* 20:184–194
- Hinkel, J., Lincke, D., Vafeidis, A. T., Perrette, M., Nicholls, R. J., Tol, R. S. J., Marzeion, B., Fettweis, X., Ionescu, C. & Levermann, A. 2014. Coastal flood damage and adaptation costs under 21st century sea-level rise. *Proceedings of the National Academy of Sciences of the United States of America*, 111, 3292–3297
- Hoad D (2016) The 2015 Paris climate agreement: outcomes and their impacts on small island states. *Island Studies Journal* 11:315–320
- Hochrainer-Stigler S, Linnerooth-Bayer J, Lorant A (2017) The European Union solidarity fund: an assessment of its recent reforms. *Mitig Adapt Strateg Glob Chang* 22:547–563
- Hopwood B, Mellor M, O'Brien G (2005) Sustainable development: mapping different approaches. *Sustain Dev* 13:38–52
- Huggel C, Muccione V, Carey M, James R, Jurt C, Mechler R (2019) Loss and damage in the mountain cryosphere. *Reg Environ Chang* 19:1387–1399
- Huggel C, Stone C, Eicken H, Hansen G (2015) Potential and limitations of the attribution of climate change impacts for informing loss and damage discussions and policies. *Clim Chang* 133:453–467
- Kates, R. W., Parris, T. M. & Leiserowitz, A. A. 2005. What is sustainable development? Goals, indicators, values, and practice. *Environment(Washington DC)*, 47, 8–21
- Kehinde, B. 2014. Applicability of risk transfer tools to manage loss and damage from slow-onset climatic risks. In: AMARATUNGA, D. & HAIGH, R. (eds.) *4th International Conference on Building Resilience, Incorporating the 3rd Annual Conference of the Android Disaster Resilience Network*
- Kemp-Benedict E, Lamontagne J, Laing T, Drakes C (2019) Climate impacts on capital accumulation in the small Island state of Barbados. *Sustainability* 11
- Lashley JG, Warner K (2015) Evidence of demand for microinsurance for coping and adaptation to weather extremes in the Caribbean. *Clim Chang* 133:101–112
- Lassa JA, Lai AYH, Goh T (2016) Climate extremes: an observation and projection of its impacts on food production in ASEAN. *Nat Hazards* 84:S19–S33
- Lincke D, Hinkel J (2018) Economically robust protection against 21st century sea-level rise. *Global Environmental Change-Human and Policy Dimensions* 51:67–73
- Lyster R (2015) A fossil fuel-funded climate disaster response fund under the Warsaw international mechanism for loss and damage associated with climate change impacts. *Transnational Environmental Law* 4:125–151
- Lyster R (2017) Climate justice, adaptation and the Paris agreement: a recipe for disasters? *Environmental Politics* 26:438–458
- Ma X, Li Y, He X, Wang W, Liu S, Gao Q (2015) Loss and damage related to climate change: connotations and response mechanism. *Chinese Journal of Population Resources and Environment* 13:55–60
- Mace MJ, Verheyen R (2016) A glimpse into the future of the climate regime: lessons from the REDD+ architecture. *Review of European Comparative & International Environmental Law* 25:197–214
- Marjanac S, Patton L (2018) Extreme weather event attribution science and climate change litigation: an essential step in the causal chain? *Journal of Energy & Natural Resources Law* 36:265–298
- Mayer B (2014) Whose 'loss and damage'? Promoting the agency of beneficiary states. *Climate Law* 4:267–300
- Mayer B (2017) Migration in the UNFCCC Workstream on loss and damage: an assessment of alternative framings and conceivable responses. *Transnational Environmental Law* 6:107–129
- Mcnamara KE, Bronen R, Fernando N, Klepp S (2018) The complex decision-making of climate-induced relocation: adaptation and loss and damage. *Clim Pol* 18:111–117
- Meshaie K (2017) Values and harms in loss and damage. *Ethics Policy & Environment* 20:129–142
- Mechler R, Schinko T (2016) Identifying the policy space for climate loss and damage. *Science* 354:290–292
- Mintz-Woo K (2018) Security and distribution, or should you care about merely possible losses? *Ethics Policy & Environment* 21:382–386
- Monnereau I, Abraham S (2013) Limits to autonomous adaptation in response to coastal erosion in Kosrae, Micronesia. *International Journal of Global Warming* 5:416–432
- Mukherji A, Sinisalo A, Nuessner M, Garrard R, Eriksson M (2019) Contributions of the cryosphere to mountain communities in the Hindu Kush Himalaya: a review. *Reg Environ Chang* 19:1311–1326

- Nordlander L, Pill M, Romera BM (2019) Insurance schemes for loss and damage: fools' gold? *Clim Pol*
- Nussbaum M (2003) Capabilities as fundamental entitlements: sen and social justice. *Fem Econ* 9:33–59
- Ourbak T, Magnan AK (2018) The Paris agreement and climate change negotiations: small Islands, big players. *Reg Environ Chang* 18:2201–2207
- Porter TM (1996) *Trust in numbers: the pursuit of objectivity in science and public life*. Princeton University Press
- Preston BL, Dow K, Berkhout F (2013) The climate adaptation frontier. *Sustainability* 5:1011–1035
- Preston CJ (2017) Challenges and opportunities for understanding non-economic loss and damage. *Ethics Policy & Environment* 20:143–155
- Pretis, F., Schwarz, M., Tang, K., Haustein, K. & Allen, M. R. 2018. Uncertain impacts on economic growth when stabilizing global temperatures at 1.5 degrees C or 2 degrees C warming. *Philosophical Transactions of the Royal Society a-Mathematical Physical and Engineering Sciences*, 376
- Putnam R (2001) Social capital: measurement and consequences. *Can J Policy Res* 2:41–51
- Rabbani G, Rahman A, Mainuddin K (2013) Salinity-induced loss and damage to farming households in coastal Bangladesh. *International Journal of Global Warming* 5:400–415
- Roberts E, Andrei S (2015) The rising tide: migration as a response to loss and damage from sea level rise in vulnerable communities. *International Journal of Global Warming* 8:258–273
- Roberts E, Andrei S, Huq S, Flint L (2015) Resilience synergies in the post-2015 development agenda. *Nat Clim Chang* 5:1024–1025
- Roberts E, Pelling M (2018) Climate change-related loss and damage: translating the global policy agenda for national policy processes. *Climate Development* 10:4–17
- Roberts E, Pelling M (2019) Loss and damage: an opportunity for transformation? *Clim Pol*
- Roberts JT, Natson S, Hoffmeister V, Durand A, Weikmans R, Gewirtzman J, Huq S (2017) How will we pay for loss and damage? *Ethics, Policy, Environment* 20:208–226
- Schinko T, Mechler R (2017) Applying recent insights from climate risk management to operationalize the loss and damage mechanism. *Ecol Econ* 136:296–298
- Schwan S, Yu X (2018) Social protection as a strategy to address climate-induced migration. *International Journal of Climate Change Strategies and Management* 10:43–64
- Scott DN, Smith AA (2017) The abstract subject of the climate migrant: displaced by the rising tides of the green energy economy. *Journal of Human Rights and the Environment* 8:30–50
- Sen A (1989) Women's survival as a development problem. *Bulletin of the American Academy of Arts and Sciences* 43:14–29
- Sen A (1999) The possibility of social choice. *Am Econ Rev*:349–378
- Sen, A. 2001. *Development as freedom*, Oxford Paperbacks
- Sen A (2004) Capabilities, lists, and public reason: continuing the conversation. *Fem Econ* 10:77–80
- Serdeczny OM, Bauer S, Huq S (2018) Non-economic losses from climate change: opportunities for policy-oriented research. *Clim Dev* 10:97–101
- Sharife K, Bond P (2013) Payment for ecosystem services versus ecological reparations: the 'green economy', litigation and a redistributive eco-debt grant. *South African Journal on Human Rights* 29:144–169
- Sharma A (2017) Precaution and post-caution in the Paris agreement: adaptation, loss and damage and finance. *Clim Pol* 17:33–47
- Sindico F (2016) Paris, climate change, and sustainable development. *Climate Law* 6:130–141
- Sonja, K. & Harald, W. 2018. Building equity in: strategies for integrating equity into modelling for a 1.5 degrees C world. *Philosophical Transactions of the Royal Society a-Mathematical Physical and Engineering Sciences*, 376
- Stabinsky D, Hoffmaister JP (2015) Establishing institutional arrangements on loss and damage under the UNFCCC: the Warsaw international mechanism for loss and damage. *International Journal of Global Warming* 8:295–318
- Stern DI (1997) The capital theory approach to sustainability: a critical appraisal. *Journal of Economic Issues* 31: 145–174
- Stiglitz JE, Sen AK, Fitouss J-P (2010) *Mismeasuring our lives: why GDP doesn't add up*. The New Press, London
- Sultan B, Defrance D, Iizumi T (2019) Evidence of crop production losses in West Africa due to historical global warming in two crop models. *Sci Rep* 9
- Surminski S, Eldridge J (2015) Observations on the role of the private sector in the UNFCCC's loss and damage of climate change work program. *International Journal of Global Warming* 8:213–230
- Taub J, Nasir N, Rahman MF, Huq S (2016) From Paris to Marrakech: global politics around loss and damage. *India Quarterly-a Journal of International Affairs* 72:317–329
- TEEB (2010) *The economics of ecosystems and biodiversity ecological and economic foundations*. London and Washington, Earthscan

- Thomas A, Benjamin L (2018a) Management of loss and damage in small island developing states: implications for a 1.5 degrees C or warmer world. *Reg Environ Chang* 18:2369–2378
- Thomas A, Benjamin L (2018b) Policies and mechanisms to address climate-induced migration and displacement in Pacific and Caribbean small island developing states. *International Journal of Climate Change Strategies and Management* 10:86–104
- Thomas A, Benjamin L (2019) Non-economic loss and damage: lessons from displacement in the Caribbean. *Clim Pol*
- Tiepolo M, Bacci M, Braccio S (2018) Multihazard risk assessment for planning with climate in the Dosso region. *Niger Climate* 6
- Tschakert P, Barnett J, Ellis N, Lawrence C, Tuana N, New M, ELRICK-BARR C, Pandit R, Pannell D (2017) Climate change and loss, as if people mattered: values, places, and experiences. *Wiley Interdisciplinary Reviews-Climate Change* 8
- Tschakert P, Ellis N, Anderson C, Kelly A, Obeng J (2019) One thousand ways to experience loss: a systematic analysis of climate-related intangible harm from around the world. *Glob Environ Chang* 55:58–72
- Van Der Geest K (2018) Landslide loss and damage in Sindhupalchok District, Nepal: comparing income groups with implications for compensation and relief. *International Journal of Disaster Risk Science* 9:157–166
- Van Der Geest K, Schindler M (2016) Brief communication: loss and damage from a catastrophic landslide in Nepal. *Nat Hazards Earth Syst Sci* 16:2347–2350
- Verchick, R. R. M. 2018. Can ‘loss and damage’ carry the load? *Philosophical Transactions of the Royal Society a-Mathematical Physical and Engineering Sciences*, 376
- Vincent K, Cull T (2014) Using indicators to assess climate change vulnerabilities: are there lessons to learn for emerging loss and damage debates? *Geogr Compass* 8:1–12
- Warner K (2012) Human migration and displacement in the context of adaptation to climate change: the Cancun adaptation framework and potential for future action. *Environment and Planning C-Government and Policy* 30:1061–1077
- Warner K (2018) Coordinated approaches to large-scale movements of people: contributions of the Paris agreement and the global compacts for migration and on refugees. *Popul Environ* 39:384–401
- Warner K, Van Der Geest K (2013) Loss and damage from climate change: local-level evidence from nine vulnerable countries. *International Journal of Global Warming* 5:367–386
- Werkheiser I (2017) Loss of epistemic self-determination in the Anthropocene. *Ethics, Policy, Environment* 20: 156–167
- Wirtz A, Kron W, Löw P, Steuer M (2014) The need for data: natural disasters and the challenges of database management. *Nat Hazards* 70:135–157
- Wrathall DJ, Oliver-Smith A, Fekete A, Gencer E, Reyes ML, Sakdapolrak P (2015) Problematising loss and damage. *International Journal of Global Warming* 8:274–294
- Yaffa S (2013) Coping measures not enough to avoid loss and damage from drought in the north Bank region of the Gambia. *International Journal of Global Warming* 5:467–482
- Zaidi RZ (2018) Beyond the Sendai indicators: application of a cascading risk lens for the improvement of loss data indicators for slow-onset hazards and small-scale disasters. *International Journal of Disaster Risk Reduction* 30:306–314

Publisher's note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

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