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What's at stake? A human well-being based proposal for assessing risk of loss and damage from climate change

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Current scientific discourse on the assessment of loss and damage from climate change focuses primarily on what is straightforwardly quantifiable, such as monetary value, numbers of casualties, or destroyed homes. However, the range of possible harms induced by climate change is much broader, particularly as regards residual risks that occur beyond limits to adaptation. In international climate policy, this has been institutionalized within the Loss and Damage discourse, which emphasizes the importance of non-economic loss and damage (NELD). Nevertheless, NELDs are often neglected in loss and damage assessments, being intangible and difficult to quantify. As a consequence, to date, no systematic concept or indicator framework exists that integrates market-based and non-market-based loss and damage. In this perspective, we suggest assessing risk of loss and damage using a climate change risk and vulnerability assessment (CRVA) framework: the Impact Chain method. This highly adaptable method has proven successful in unraveling complex risks in socio-ecological systems through a combination of engaging (political) stakeholders and performing quantitative data analysis. We suggest expanding the framework's logic to include not only the sources but also the consequences of risk by conceptualizing loss and damage as harm to nine domains of human well-being. Our approach is consistent with the risk conceptualization by the Intergovernmental Panel on Climate Change (IPCC). Conceptualization and systematic assessment of the full spectrum of imminent loss and damage allows a more comprehensive anticipation of potential impacts on human well-being, identifying vulnerable groups and providing essential evidence for transformative and comprehensive climate risk management.

KEYWORDS

loss and damage, NELD, human well-being, risk assessment, indicators, climate change

Need for a holistic and human needs-oriented approach for assessing loss and damage

It is projected that climate change will have increasingly harmful impacts on the natural environment, as well as on human society and individuals (Field, 2014). These impacts are discussed under the umbrella term Loss and Damage. Policy and decision-makers worldwide are urged to act against climate change through mitigation and adaptation, to keep loss and damage from residual climate-related risks to a minimum. Nevertheless, current mitigation and adaptation trajectories indicate that residual risks are occurring and will become increasingly common globally (Nachmany and Mangan, 2018; Watson et al., 2019). Accordingly, decisions will increasingly be accompanied by the question: What is at stake once risks manifest into actual impacts? Therefore, there is a clear need for risk assessments of loss and damage beyond the limits of adaptation.

Assessing (potential) loss and damage is not a trivial task, as experienced harm can be intangible and not clearly quantifiable (Serdeczny et al., 2018; Chiba et al., 2019; McNamara and Jackson, 2019). Assessments, whether ex ante risk assessments or ex post impact assessments, are the much-needed base of evidence of what is at stake when climate risks manifest. However, existing assessments tend to focus on monetary valuation or other tangible aspects of loss and damage, such as the number of destroyed homes or casualties (Gall, 2015; Gawith et al., 2016). Such evaluations are heavily produced by, for one thing, the disaster risk community and secondly the insurance industry (Gall, 2015), whose interests lie in the first response to disasters and in resulting monetary damages respectively. Nevertheless, the straightforwardly quantifiable aspects alone do not reflect the full spectrum of harm experienced by those affected (Gawith et al., 2016; Serdeczny et al., 2018).

Climate risks and impacts may, for example, also entail mental health disorders, inaccessible sanitation, reduced mobility, disrupted school service, impaired collaboration between governments and communities and all its implications (Chiba et al., 2019), involuntary relocation (Pill, 2020), a lost sense of belonging to a place (Morrissey and Oliver-Smith, 2013). Moreover, it spans harm to cultural heritages, biodiversity, ecosystems or to indigenous and local knowledge (Fankhauser et al., 2014; Tschakert et al., 2019).

These consequences are referred to as non-economic loss and damage (NELD) or non-market based, as opposed to market-based loss and damage, and are regularly defined as harm to goods and services that are not commonly traded in markets (McShane, 2017; Serdeczny et al., 2018; McNamara and Jackson, 2019; van der Geest and Warner, 2020). NELD are often assessed explorative through first hand experiences, surveys and narratives and less often measured through indicators (Vincent and Cull, 2014; Van der Geest and Warner, 2015).

Neglect of NELDs in quantitative indicator-based assessments due to their intangibility and their resistance to systemization and quantification has led to the current lack of a systematic conceptualization of them. However, there is growing evidence of loss and damage in this category (Cissé et al., 2022). While some approaches have been developed to categorize and derive typologies from the loss and damage literature (Fankhauser et al., 2014; Tschakert et al., 2017, 2019; Boda et al., 2021), no holistic conceptualization exists at present. However, without a conceptual and applicable framework that overcomes the divide between market- and non-market-based loss and damage, much of it, especially in the non-market-based domain, might go unnoticed by authorities and remain unaddressed.

The indicator-based climate change risk assessment method "Impact Chain method" (Fritzsche et al., 2014; GIZ, 2017; Zebisch et al., 2021) became popular due to its ability to dismantle climate risks into its components vulnerability, exposure and hazard, to translate them into quantifiable indicators and to identify adaptation measures. The method employs a mixed-method approach that combines close stakeholder-researcher collaboration with operational, quantitative data analysis. The workflow is described step-by-step in the "Vulnerability Sourcebook" and the "Risk Supplement to the Vulnerability Sourcebook" (Fritzsche et al., 2014; GIZ, 2017). The method spans a set of tools to assess integrated risks within complex socio-ecological systems, and it is explicitly designed to consider locally specific conditions and needs. Further, it can raise awareness and foster risk ownership among policy- and decision-makers (Kabisch et al., 2014; Greiving et al., 2015; Kienberger et al., 2016). Especially important in this regard is that it provides strategies to systematize, weight and prioritize indicators that do not require monetary quantifications and, thus, enables weighting and combining straightforwardly quantifiable and less tangible factors into a single assessment.

In the Impact Chain framework, risk is, in line with IPCC framings, conceptualized as a function of vulnerability, hazard and exposure factors (IPCC, 2022). We argue that this logic can be extended to: Once risk manifests into impacts, loss and damage occurs. Loss and damage, in turn, needs to be conceptualized into its constituents, similar to risk being conceptualized as hazard, exposure and vulnerability.

Therefore, in this perspective we first discuss a possible conceptualization of loss and damage that supports indicator definition and does not require separating market from non-market based loss and damage. To this end, we build on reports and studies of occurred loss and damage and systemize them based on concepts of human well-being, which correspond to the evidence of already occurred loss and damage (Annex I).

Second, we explain how this conceptualization is integrable with the Impact Chain method and the wider IPCC risk framing.

A systematic conceptualization, integrable with an effective assessment method may enable better prioritization and systematic monitoring of what is worth protecting from potentially escalating loss and damage and at what cost. If we fail to prioritize and protect what we value, we may learn that "what is important, yet not sufficiently valued, may only become apparent when it is lost, at times irretrievably" (Tschakert et al., 2017).

Bringing loss and damage from climate change and human well-being together

The concept of human well-being is concerned with the question of what humans require to lead good lives, no matter the context, culture, or time. Human well-being is generally understood to consist of a range of non-substitutable or constitutively incommensurable determinants that must all be fulfilled to some degree (Fankhauser et al., 2014). While no one claims to have found the definitive set of these determinants, the concept is largely accepted and widely discussed. In fact, human well-being is considered by some as a promising candidate to replace economic growth as the new overall aim for sustainable development (Verma, 2017; Lutz et al., 2021). This concept is already influencing important development programs, such as the Human Development Index (UNDP, 1990), the Millennium Development Goals (UN, 2015), Sustainable Development Goal 3: Good health and well-being (UNDP, 2016), and more recently, the vividly discussed well-being indicator "Years of good life" (YoGL) (Lutz et al., 2021) and Project Drawdown (Jameel et al., 2022), which seeks to find synergetic solutions at the intersection between planetary and human well-being.

Table 1 presents a synthesis of well-being domains drawn from two central publications to systematically assess loss and damage from climate change. From a systematic assessment of more than 100 published case studies that "make visible and concrete what matters most to people and what is at stake," Tschakert et al. (2019) presents evidence for 18 NELD domains. Similarly, a working paper by Fankhauser et al. (2014) for the United Nations Framework Convention on Climate Change (UNFCCC), which is typically cited when referencing NELD domains, lists eight domains; however, these are only examples of a list of undefined length.

In addition to these two core pieces of literature, we build our conceptualization on two central concepts of human well-being. The first, the gross national happiness (GNH) index, is one of the best-known indicator frameworks for holistic assessment of human well-being. The GNH is known for its regular use in the Royal Kingdom of Bhutan as an alternative development indicator (Verma, 2017), and is used with modifications around the world at the national and sub-national levels. It challenges development framings based on gross domestic product (GDP) growth, which is in line with other recent tendencies to pull focus away from GDP and toward sustainable development framings in measuring human well-being (Costanza et al., 2014). The other human well-being concept we rely on for this study is laid out in Gough (2017): "Heat, Greed and Human Need–Climate change, capitalism and sustainable wellbeing." In this book, Gough defines domains of universal human need based on eudemonic psychology (autonomy, competence, and relatedness). These universal needs relate to a set of basic and intermediate needs and are sharply distinct from their respective satisfiers, which do differ by context, culture, and time (Gough, 2017; Max-Neef, 2017).

Assessing loss and damage with the impact chain method and conceptual embedding with the IPCC's risk framework

We propose to link these categories of loss and damage to the IPCC's risk framework, which is undergoing heavy use in assessments of current and future climate-related risk.

First introduced in the IPCC's Special Report on Extreme Events (Field et al., 2012) the risk framework has been further developed in recent years to include the concept of adaptation limits, which is of crucial importance for the discourse on loss and damage from climate change. The IPCC's 5th Assessment Report (Field, 2014) identified important biophysical, financial, social, institutional, and cultural barriers to adaptation, which can lead to soft and hard adaptation limits (Dow et al., 2013; Klein et al., 2015). The Special Report on Global Warming of 1.5°C (SR1.5) collected scientific evidence related to these limits for the first time (Roy et al., 2018). Moreover, the SR1.5 synthesis presented the first evidence that relates loss and damage to adaptation limits and residual climate-related risk (after adaptation), which has been substantiated by the contribution of WG II to the AR6 (IPCC, 2022c).

With the SROCC (Pörtner et al., 2019), the concept of adaptation limits has been embedded into the IPCC's risk framework (see Figure 1). The risk framework has been updated to explicitly consider limits to adaptation in these three risk domains (Mechler et al., 2020).

We embed our conceptual extension of a human well-being based categorization of loss and damage into this wider theoretical framing (Figure 1). Residual risks are risks that cannot be eliminated through actions to reduce hazard, exposure and vulnerability, i.e., they lie beyond the limits to adaptation. Once residual risks manifest we speak of impacts, which in turn cause loss and damage.

TABLE 1 Consolidated domain suggestions based on well-being and loss and damage domains as identified in Fankhauser et al. (2014), Gough (2017), Verma (2017), and Tschakert et al. (2019).

Loss and damage domain based on consolidated human well-being	Description
Physical and mental health	- Being alive (Fankhauser et al., 2014)
	- Getting through daily activities without fatigue or physical stress (Verma, 2017)
	- Being able to experience life satisfaction (Verma, 2017)
Material living standards	- Access to nutritious food and water (Gough, 2017)
	- Protective housing, asset ownership (Gough, 2017)
	- Income-generating activities (Tschakert et al., 2019)
	- Economic security (Verma, 2017)
Functioning ecosystems	- Supporting, provisioning, and regulating cultural functions (Costanza et al., 2014; Fankhauser et al., 2014; Tschakert et al., 2019)
Functioning communities and primary relationships	- Social cohesion between individuals, family, and community members (Tschakert et al., 2019)
	- Volunteering, solidarity, informal safety nets (Verma, 2017; Tschakert et al., 2019)
	- Sense of belonging to a place (Morrissey and Oliver-Smith, 2013)
Cultural heritage and identity	- Shared practices, narratives, and customs that provide meaning and structure to people's everyday lives (Tschakert et al., 2019)
	- Historic buildings (Fankhauser et al., 2014)
	- Traditional knowledge, festivals, norms, and creative arts (Fankhauser et al., 2014; Verma, 2017)
	- Help individuals to understand themselves and what is expected of them (Gough, 2017)
	- Language and socially specific skills (Gough, 2017)
Knowledge and education	- Local, indigenous, and community knowledge (Tschakert et al., 2019)
	- Formal education (Verma, 2017)
	- Values and skills (Gough, 2017)
	- Often strongly linked to the environment, and spiritual and cultural customs
	- Contribute to social cohesion and identity (Fankhauser et al., 2014)
Governance and participation	- Human dignity (Shultziner, 2004)
	- Being able to lead legal and just lives (Tschakert et al., 2019)
	- Being able to participate in government decisions (Verma, 2017)
	- Capacity to self-govern in a sovereign manner under the jurisdiction of a state (Fankhauser et al., 2014; Tschakert et al., 2019)
	- The "critical autonomy" to "compare cultural rules, to reflect upon the rules of one's own culture, to work with others to change them and, in extremis, to move to another culture" (Gough, p. 44).
	- Mobility, travel, no involuntary displacement (Fankhauser et al., 2014).
Self-determination and time-use	- Having the capacity to lead autonomous lives, have control over their lives (Gough, 2017)
	- Be valued, respected, and treated equally (Tschakert et al., 2019)
	- Balance between time spent on work, non-work and sleep (Verma, 2017)
A desirable future[a]	- Not having to apply "erosive coping strategies" such as selling productive assets or taking children out of school for additional household income (Van der Geest and Warner, 2015)
	- Having reason to believe that the future will be better than the present, that one's children will have it better, or that a life full of hardship will be compensated by a rewarding afterlife/rebirth

[a]During an exercise of assigning real-world loss and damage examples from Alston and Kent (2004) to the well-being domains, it became apparent that some examples were not satisfactorily assignable. In particular, these were the ones that are related to concerns about how the future will unfold and situations that require coping strategies that entail adverse future implications. Van der Geest and Warner (2015) call these "erosive coping strategies": Coping strategies with negative implications for future livelihood security, such as selling productive assets or taking children out of school for additional household income. To cover the impacts that take away from 'belief in a secure future', we have added the domain "A desirable future". The description column gives examples explicitly mentioned in the literature. The full table of domains given in the literature can be found in Annex I.

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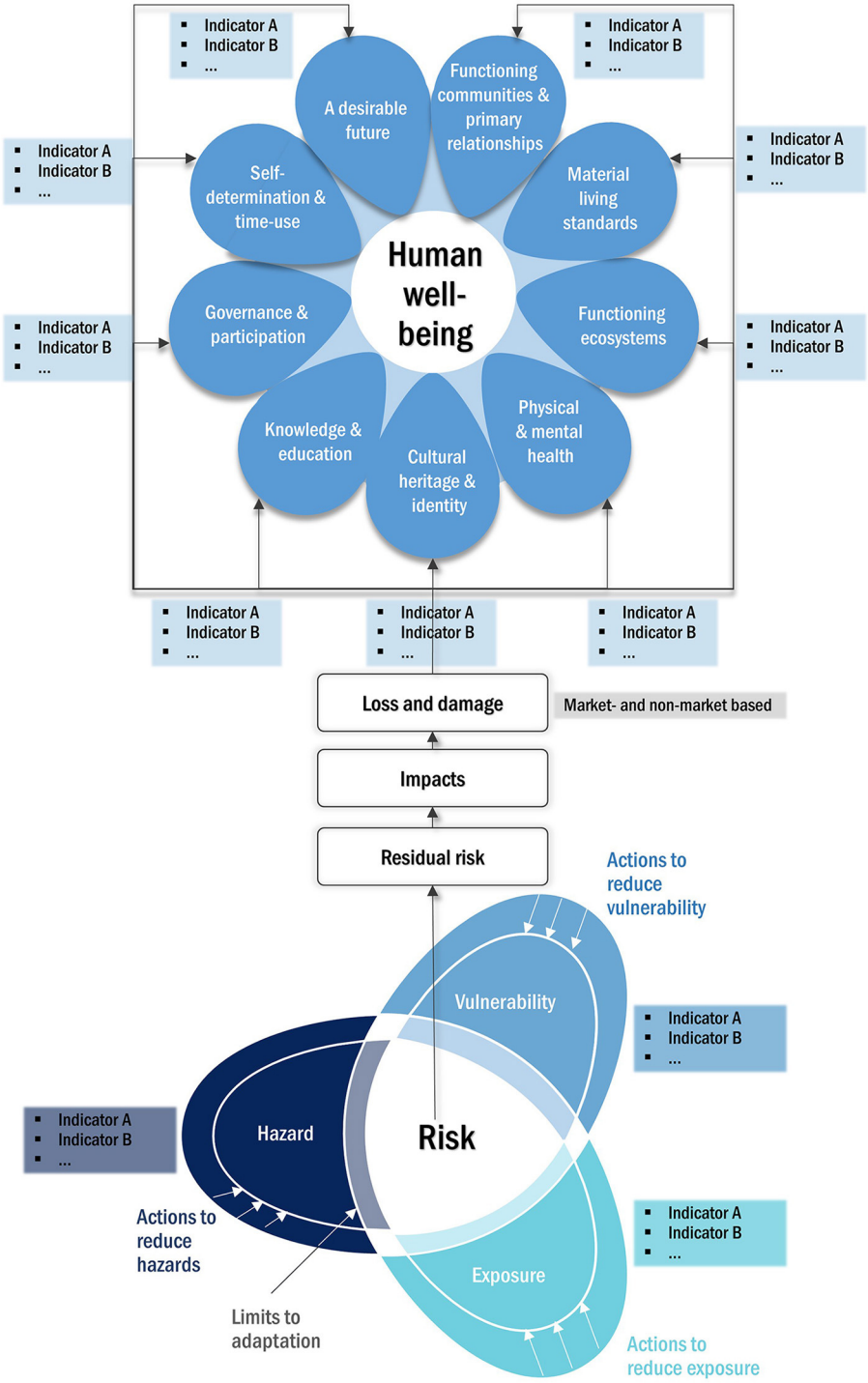

FIGURE 1
Human well-being as an approach to identify market-based and non-market-based loss and damage from climate-related risks. Climate-related risks manifest through a combination of three domains: hazard, exposure, and vulnerability. In all three dimensions, risk reduction measures may be taken, but simultaneously there may be limits to adaptation.

Loss and damage causes harm to human well-being. We propose to assess loss and damage and their respective relationships with domains of human well-being in an indicator-based manner.

In an operational risk assessment this could mean that instead of, or in addition to, identifying and quantifying risk contribution factors i.e., indicators to quantify hazard, exposure and vulnerability, the consequences of risk manifestations are identified and, where possible, quantified as well. Naturally, this is not a trivial task and requires a robust and extensive set of methods and tools. However, risk assessment strategies are continuously evolved and are becoming more sophisticate. Existing risk assessment methods, such as the Impact Chain method (Fritzsche et al., 2014; GIZ, 2017; Zebisch et al., 2021) offer ways to systemize tangible and intangible factors that contribute to a particular risk and provide quantification strategies away from monetary evaluations.

The Impact Chain method integrates the IPCC's risk framework and has proven that it can produce relevant and actionable insights for policy- and decision-making and is applicable in a broad range of contexts (Menk et al., 2022; André et al., forthcoming). The loss and damage related results produced by this method would in turn be integrable with comprehensive climate risk management approaches such as those given by Schinko et al. (2019) and Hagen et al. (forthcoming).

Discussion and conclusions

We proposed a systematization of loss and damage that builds on nine categories of human well-being. We understand loss and damage as harm caused by manifestations of residual risks beyond limits to adaptation. We propose this systematization to be operationalized within the context of climate-related risk assessments, in particular the Impact Chain method, building on the IPCC's risk framework. One of our aims was to lay out a path to narrow the gap between monetary assessments of loss and damage and qualitative NELD assessments. This is, because there is a need to synthesize both realms into one effective monitoring framework (Kurian et al., 2019). We argue that loss and damage indicators can be developed and monitored by the methods and tools already available to the Climate Change Adaptation, Disaster Risk Reduction and related communities. The indicators may be developed under nine "umbrella" categories that are for loss and damage what "hazard, vulnerability and exposure" is for risk. Through a close collaboration between decision makers and researchers, actionable, locally specific decision-support may be provided, aiming to reduce possible harm to human well-being. We draw on studies that describe loss and damage and studies that propose determinants of human well-being to systematize values shared by humans throughout space and time.

To pay due respect to planetary boundaries, we suggest that conceptualizing well-being is only possible between the planet's ecological ceiling and socially negotiated foundations that no one should fall below. Resilient and well-functioning ecosystems are an indispensable foundation to human well-being. Although the contribution of a component to the functioning of an ecosystem might not be scientifically understood yet, its disappearance can severely impact human well-being and must be avoided (Rockström et al., 2009). Thus, we argue that the disturbance of ecosystems be restricted to a degree that would foster well-being while not exceeding any planetary boundaries (Rockström et al., 2009; Steffen et al., 2015). This entails remaining within the "safe and just space for humanity to thrive" as indicated by Raworth's idea of "doughnut economics," bordered by the social foundation that must be ensured and the ecological ceiling that should not be exceeded (Raworth, 2017).

Taking this extended understanding of loss and damage based on human well-being, we aim to shift the discourse away from domination by monetary evaluation. Using simply cost-benefit considerations, poor and less-privileged communities tend to be deprioritized, and unjust or unsustainable structures tend to be reestablished (Preston et al., 2013). Furthermore, monetary evaluations provide the false impression that all loss and damage can be reversed if only enough money is allocated.

The well-being determinants presented herein are to be understood as a starting point for discussion, not a definitive answer to what universally defines human well-being. Harmed human well-being and social consequences in general through loss and damage from climate change are heavily underexplored, and detailed empirical studies are lacking.

We see three main challenges with this operationalization that need to be addressed by future research. The first is to determine a clear cause-effect relationship between a climate impact and an experienced impairment of well-being. Chiba et al. (2019) managed to attribute decreased mental health or trust in government to climate change loss and damage. However, the causal chain from climate impact to impaired well-being to adaptive action can be challenging to untangle, particularly for slow-onset/medium-onset processes, such as droughts. Future research efforts should therefore seek a way to attribute a clear cause-effect relationship between climate impact, harmed human well-being, and adaptive decision-making to explore other techniques to express decisions and their influencing factors.

The other conceptual challenge concerned thresholds and how to integrate them. We suggest that human well-being has a lower threshold, which we, in accordance with Raworth (2017), term the social foundation. When someone falls below the social foundation in any of the well-being domains, they experience loss and damage. To the contrary, the planet dictates a certain boundary to humanity: the ecological ceiling. At some point as we strive for well-being, we must reach a certain material living standard that we deem sufficient that is still well within

the holding capacity of our environment. However, specifying such thresholds in actual real-world examples is challenging, as what should be considered above the social foundation is perceived differently between individuals and across cultures, and is continuously negotiated in society. Further research should seek a pragmatic means of conceptualizing the two thresholds for the purpose of assessing loss and damage.

The third challenge is the availability of data. While discussions about risk factors and their relationships can be solely based on expert or stakeholder knowledge, quantifying the indicators is heavily reliant on data. The absence of appropriate data has been found to be, to date, a major challenge in the application of the Impact Chain method (Menk et al., 2022). This challenge would be equally present when aiming to populate loss and damage indicators with data. However, the participatory awareness-building steps can be conducted even in the absence of quantitative data. To some extent, lacking data might be compensated through data-light approaches, such as utilizing expert knowledge to derive indicator weights or to integrate uncertainty (Melo-Aguilar, forthcoming; Kurian and Kojima, 2021). However, for a comprehensive indicator quantification, more research in the direction of utilizing citizen science, socioeconomic modeling or agent-based modeling would be necessary (Biggs et al., 2021; Kurian and Kojima, 2021).

We consider this perspective an opportunity to raise awareness for the widespread absence of data and knowledge about the possible consequences of residual risks manifesting. Some scholars warn that attempts to formalize and quantify harm in an indicator-like manner will lead to overshadowing factors that cannot easily be quantified (Tschakert et al., 2017). We do not challenge this, but we argue that attempting a quantification has the potential to increase awareness, and it also provides the opportunity to raise awareness for gaps in knowledge and data. We furthermore argue that collecting qualitative and quantitative data on harms to well-being could support sustainable development and decarbonization efforts, offering an evidence base for decision-making in addition to monetary valuations. Evidence of avoided loss and damage through mitigation and adaptation could also function as a performance indicator that could complement GDP. A robust and structured evidence base is crucial for policy and decision makers who seek to justify transformative risk management strategies that are not limited to gradual adjustments, but which seek to fundamentally alter systemic structures that lead to loss and damage (Kates et al., 2012; Deubelli and Mechler, 2020; Roberts and Pelling, 2020). Transformational risk management is moving away from adaptation practices that reconstruct vulnerable states of being and instead foster well-being and development (Wrathall et al., 2015). Viewed through this lens, prospective assessments of potential market- and non-market-based loss and damage from climate change constitute "an opportunity to scrutinize and address the root causes of vulnerability" (Roberts and Pelling, 2020).

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

Conceptualization, methodology, and writing—review and editing: LM, TS, VK, IH, and SK. Data curation: LM. Investigation: LM and VK. Funding acquisition and project administration: TS. Supervision: SK and TS. Visualization: LM, SK, and TS. Writing—original draft: LM and TS. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fclim.2022.1032886/full#supplementary-material

References

Alston, M, and Kent, J. (2004) *Social Impacts of Drought*.

André, K., Swartling, A. G., Englund, M., Menk, L., Nii Armah Nyadzi Attoh, E. M., Milde, K., et al. (forthcoming). Improving stakeholder engagement in climate change risk assessments: insights from six co-production initiatives in Europe. *Front. Clim.*

Biggs, R., De Vos, A., Preiser, R., Clements, H., Maciejewski, K., and Schlüter, M. (2021). *The Routledge Handbook of Research Methods for Social-Ecological Systems*. Milton Park: Taylor and Francis. doi: 10.4324/9781003021339

Boda, C. S., Faran, T., Scown, M., Dorkenoo, K., Chaffin, B. C., Nastar, M., et al. (2021). Loss and damage from climate change and implicit assumptions of sustainable development. *Clim. Change* 164, 13. doi: 10.1007/s10584-021-02970-z

Chiba, Y., Prabhakar, S. V., and Islam, M. A. (2019). Addressing Non-economic loss and damage associated with climatic events: cases of Japan and Bangladesh. *APN Sci. Bull.* 9, 740. doi: 10.30852/sb.2019.740

Cissé, G., McLeman, R., Adams, H., Aldunce, P., Bowen, K., Campbell-Lendrum, D., et al. (2022). "Health, wellbeing, and the changing structure of communities," in *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, eds H. -O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, and B. Rama (Cambridge; New York, NY: Cambridge University Press), 1041–1170, doi: 10.1017/9781009325844.009

Costanza, R., Kubiszewski, I., Giovannini, E., Lovins, H., McGlade, J., Pickett, K. E., et al. (2014). Development: time to leave GDP behind. *Nature* 505, 283–285. doi: 10.1038/505283a

Deubelli, T. M., and Mechler, R. (2020). Perspectives on transformational change in climate risk management and adaptation. *Environ. Res. Lett.* 16:053002. doi: 10.1088/1748-9326/abd42d

Dow, K., Berkhout, F., Preston, B. L., Klein, R. J., Midgley, G., and Shaw, M. R. (2013). Limits to adaptation. *Nat. Clim. Change* 3, 305–307. doi: 10.1038/nclimate1847

Fankhauser, S., Dietz, S., and Gradwell, P. (2014). "Non-economic losses in the context of the UNFCCC work programme on loss and damage," in *Policy Paper, Centre for Climate Change Economics and Policy*, Grantham Research Institute on Climate Change and the Environment.

Field, C. B. (2014). *Climate Change 2014–Impacts, Adaptation and Vulnerability: Regional Aspects*. Cambridge: Cambridge University Press. doi: 10.1017/CBO9781107415379

Field, C. B., Barros, V., Stocker, T. F., and Dahe, Q. (2012). *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: Special Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press. doi: 10.1017/CBO9781139177245

Fritzsche, K., Schneiderbauer, S., Bubeck, P., Kienberger, S., and Buth, M., Zebisch, M, et al. (2014). *The Vulnerability Sourcebook: Concept and Guidelines for Standardised Vulnerability Assessments* GIZ, Eurac adelphi.

Gall, M. (2015). The suitability of disaster loss databases to measure loss and damage from climate change. *Int. J. Global Warm.* 8, 170–190. doi: 10.1504/IJGW.2015.071966

Gawith, D., Daigneault, A., and Brown, P. (2016). Does community resilience mitigate loss and damage from climaterelated disasters? Evidence based on survey data. *J. Environ. Plan. Manag.* 59, 2102–2123. doi: 10.1080/09640568.2015.1126241

GIZ, E. (2017). *Risk Supplement to the Vulnerability Sourcebook. Guidance on How to Apply the Vulnerability Sourcebook's Approach with the New IPCC AR5 Concept of Climate Risk*. Bonn: Giz Bonn.

Gough, I. (2017). *Heat, Greed and Human Need: Climate Change, Capitalism and Sustainable Wellbeing*. Cheltenham: Edward Elgar Publishing. Available online at: https://www.iangough.com/heat-greed-and-human-need (accessed March 17, 2021). doi: 10.4337/9781785365119

Greiving, S., Zebisch, M., Schneiderbauer, S., Fleischhauer, M., Lindner, C., Lückenkötter, J., et al. (2015). A consensus based vulnerability assessment to climate change in Germany. *Int. J. Clim. Change Strat. Manag.* 7, 306–326. doi: 10.1108/IJCCSM-11-2013-0124

Hagen, I., Allen, S., Bahinipati, C.S., Frey, H., Huggel, C., Karabaczek, V., et al. (forthcoming). "An International Perspective on Comprehensive Climate Risk Management: Experiences from Peru, India and Austria.

IPCC (2022c). "Climate change 2022: mitigation of climate change," in *Contribution of Working Group III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge and New York, NY: Cambridge University Press. doi: 10.1017/9781009157926

IPCC. (2022). "Annex II: Glossary," in *Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change*, eds H. -O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (Cambridge; Mew York, NY: Cambridge University Press), 2897–2930. doi: 10.1017/9781009325844.029

Jameel, Y., Patrone, C. M., Patterson, K. P., and West, P. C. (2022). "*Climate-Poverty Connections: Opportunities for Synergistic Solutions at the Intersection of Planetary and Human Well-Being*," Roosevelt County: Project Drawdown. doi: 10.55789/y2c0k2p2

Kabisch, S., Chakrabarti, R., Wolf, T., Kiewitt, W., Gorman, T., Chaturvedi, A., et al. (2014). Climate change impact chains in the water sector: observations from projects on the East India Coast. *J. Water Clim. Change* 5, 216–232. doi: 10.2166/wcc.2013.118

Kates, R. W., Travis, W. R., and Wilbanks, T. J. (2012). Transformational adaptation when incremental adaptations to climate change are insufficient. *Proc. Natl. Acad. Sci.* 109, 7156–7161. doi: 10.1073/pnas.1115521109

Kienberger, S., Borderon, M., Bollin, C., and Jell, B. (2016). Climate change vulnerability as- sessment in Mauritania: Reflections on data quality, spatial scales, aggregation and visualizations. *GI_Forum J.* 1, 167–175. doi: 10.1553/giscience2016_01_s167

Klein, R. J., Midgley, G., Preston, B. L., Alam, M., Berkhout, F., Dow, K., et al. (2015). "Adaptation opportunities, constraints, and limits," in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, vol 899*. Cambridge: Cambridge University Press.

Kurian, M., and Kojima, Y. (2021). *Boundary Science: Re-Imagining Water-Energy-Food Interactions in the Context of a Data Ligh Approach to Monitoring the Environment-Development Nexus*. Amsterdam: Elsevier. doi: 10.1016/B978-0-323-88473-0.00003-8

Kurian, M., Scott, C., Reddy, V. R., Alabaster, G., Nardocci, A., Portney, K., et al. (2019). One swallow does not make a summer: siloes, trade-offs and synergies in the water-energy-food nexus. *Front. Environ. Sci.* 7, 32. doi: 10.3389/fenvs.2019.00032

Lutz, W., Striessnig, E., Dimitrova, A., Ghislandi, S., Lijadi, A., Reiter, C., et al. (2021). Years of good life is a well-being indicator designed to serve research on sustainability. *Proc. Natl. Acad. Sci.* 118, e1907351118. doi: 10.1073/pnas.1907351118

Max-Neef, M. (2017). "Development and human needs," in *Development Ethics* (New York, NY: Routledge), 169–86. doi: 10.4324/9781315258003-14

McNamara, K. E., and Jackson, G. (2019). Loss and damage: a review of the literature and directions for future research. *Wiley Interdisc. Rev. Clim. Change* 10, 564. doi: 10.1002/wcc.564

McShane, K. (2017). Values and harms in loss and damage. *Ethics Policy Environ.* 20, 129–142. doi: 10.1080/21550085.2017.1342960

Mechler, R., Singh, C., Ebi, K., Djalante, R., Thomas, A., James, R., et al. (2020). Loss and damage and limits to adaptation: recent ipcc insights and implications for climate science and policy. *Sustain. Sci.* 15, 1245–1251. doi: 10.1007/s11625-020-00807-9

Melo-Aguilar, C,. Agulles, M., and Jordà, G. (forthcoming) Introducing uncertainties in composite indicators. The case of the impact chain risk assessment framework. *Front. Clim.* 221.

Menk, L., Terzi, S., Zebisch, M., Rome, E., Lückerath, D., Milde, K., et al. (2022). Climate change impact chains: a review of applications, challenges, and opportunities for climate risk and vulnerability assessments. *Weather Clim. Soc.* 14:619–626. doi: 10.1175/WCAS-D-21-0014.1

Morrissey, J., and Oliver-Smith, A. (2013). Perspectives on non-economic loss and damage: understanding values at risk from climate change. *Loss Damage Vulner. Count. Initiat. Rep.* 1–3. Available online at: http://ailac.org/wp-content/uploads/2014/08/7308.pdf

Nachmany, M., and Mangan, E. (2018). *Aligning National and International Climate Targets*. London: CCCEP at University of Leeds.

Pill, M. (2020). "Planned relocation from the impacts of climate change in Small Island Developing States: the intersection between adaptation and loss and damage," in *Managing Climate Change Adaptation in the Pacific Region* (Cham: Springer), 129–149.

Pörtner, H. O., Roberts, D. C., Masson-Delmotte, V., Zhai, P., Tignor, M., Poloczanska, E., et al. (2019). The ocean and cryosphere in a changing climate. *IPCC Spec. Rep. Ocean Cryosph. Chang. Clim.* doi: 10.1017/9781009157964

Preston, B. L., Dow, K., and Berkhout, F. (2013). The climate adaptation frontier. *Sustainability* 5, 1011–1035. doi: 10.3390/su5031011

Raworth, K. (2017). *Doughnut Economics: Seven Ways to Think like a 21st-Century Economist*. Hartford: Chelsea Green Publishing.

Roberts, E., and Pelling, M. (2020). Loss and damage: an opportunity for transformation? *Clim. Policy* 2020, 105–118. doi: 10.1080/14693062.2019.1680336

Rockström, J., Steffen, W., Noone, K., Persson, Å., Chapin, F. S., Lambin, E., et al. (2009). Planetary boundaries: exploring the safe operating space for humanity. *Ecol. Soc.* 14, 1–33. doi: 10.5751/ES-03180-140232

Roy, J., Tschakert, P., Waisman, H., Abdul Halim, S., Antwi-Agyei, P., Dasgupta, P., et al. (2018). "Sustainable development, poverty eradication and reducing inequalities," in *Global Warming of 1.5°C. An IPCC Special Report on the Impacts of Global Warming of 1.5°C Above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*, eds V. Masson-Delmotte, P. Zhai, H. O. Pörtner, D. Roberts, J. Skea, P. R. Shukla, A. Pirani, W. Moufouma-Okia, C. Péan, R. Pidcock, S. Connors, R. B. R. Matthews, Y. Chen, X. Zhou, M. I. Gomis, E. Lonnoy, T. Maycock, M. Tignor, and T. Waterfield (In Press).

Schinko, T., Mechler, R., and Hochrainer-Stigler, S. (2019). "The risk and policy space for loss and damage: integrating notions of distributive and compensatory justice with comprehensive climate risk management," in *Loss and Damage from Climate Change* (New York, NY: Springer), 83–110. doi: 10.1007/978-3-319-72026-5_4

Serdeczny, O. M., Bauer, S., and Huq, S. (2018). Non-economic losses from climate change: opportunities for policy-oriented research. *Clim. Develop.* 10, 97–101. doi: 10.1080/17565529.2017.1372268

Shultziner, D. (2004). *Human Dignity-Functions and Meanings*. Global Jurist Topics 3.3.

Steffen, W., Richardson, K., Rockström, J., Cornell, S. E., Fetzer, I., Bennett, E. M., et al. (2015). Planetary boundaries: guiding human development on a changing planet. *Science* 347:1259855. doi: 10.1126/science.1259855

Tschakert, P., Barnett, J., Ellis, N., Lawrence, C., Tuana, N., New, M., et al. (2017). Climate change and loss, as if people mattered: values, places, and experiences. *Wiley Interdiscipl. Rev. Clim. Change* 8, 476. doi: 10.1002/wcc.476

Tschakert, P., Ellis, N. R., Anderson, C., Kelly, A., and Obeng, J. (2019). One thousand ways to experience loss: a systematic analysis of climate-related intangible harm from around the world. *Global Environ. Change* 55: 58–72. doi: 10.1016/j.gloenvcha.2018.11.006

UN (2015). *The Millenium Development Goals Report 2015*. New York, NY: UN.

UNDP (1990). *Human Development Report 1990: Concept and Measurement of Human Development*. New York: UNDP.

UNDP (2016). *Goal 3: Good Health and Well-Being*. New York, NY: UNDP.

Van der Geest, K., and Warner, K. (2015). "Vulnerability, coping and loss and damage from climate events," in *Hazards, Risks and Disasters in Society* (Amsterdam: Elsevier), 121–44. doi: 10.1016/B978-0-12-396451-9.00008-1

van der Geest, K., and Warner, K. (2020). Loss and damage in the IPCC fifth assessment report (working group II): a text-mining analysis. *Clim. Policy* 20, 729–42. doi: 10.1080/14693062.2019.1704678

Verma, R. (2017). Gross national happiness: meaning, measure and degrowth in a living development alternative. *J. Polit. Ecol.* 24, 476–490. doi: 10.2458/v24i1.20885

Vincent, K., and 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. doi: 10.1111/gec3.12105

Watson, R., McCarthy, H., Canziani, P., Nakicenovic, N., and Hisas, L. (2019). *The Truth behind the Climate Pledges*. Available online at: https://pure.iiasa.ac.at/id/eprint/16143/1/The%20Truth%20Behind%20the%20Climate%20Pledges.pdf

Wrathall, D. J., Oliver-Smith, A., Fekete, A., Gencer, E., Reyesm, M. L., and Sakdapolrak, P. (2015). Problematising loss and damage. *Int. J. Global Warm.* 8, 274–294. doi: 10.1504/IJGW.2015.071962

Zebisch, M., Schneiderbauer, S., Fritzsche, K., Bubeck, P., Kienberger, S., Kahlenborn, W., et al. (2021). The vulnerability sourcebook and climate impact chains—a standardised framework for a climate vulnerability and risk assessment. *Int. J. Clim. Change Strat. Manag.* 30, 35–59. doi: 10.1108/IJCCSM-07-2019-0042