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We need a global assessment of avoidable climate change risks

Global warming will have myriad impacts. To understand the urgency of emissions reductions, policymakers need a full analysis of what may be at stake.

Peter A. Stott, Y. T. Eunice Lo, John H. Marsham, David Obura, Tom H. Oliver, Matthew D. Palmer, Nicola Ranger, Simon Sharpe, Rowan Sutton

Climate change presents many threats to life on our planet: a global food crisis, deaths of millions of people from extreme heat, intense droughts, floods and collapses of crucial ecosystems. Some island states and cities might disappear beneath rising seas. Conflict, state failure and mass migration could escalate.

Policymakers and citizens are aware of some of these risks, but they don’t necessarily know how severe they will be, how rapidly they might emerge or which risks are avoidable. Government leaders need to know the severity and urgency of such risks to help them make well informed decisions and set priorities. So far, they only have a partial view.

For example, policymakers might realize that sea level rise requires spending more money on flood defences, yet neglect that parts of a large city such as London, New York or Mumbai might have to be abandoned. They might be aware that more people will die in heat waves in a hotter climate yet be unprepared for mass casualties if tens of thousands of people in one region were to die in conditions exceeding the limits of human tolerance.

Without a clear view of what is at stake, it is difficult – or even impossible – to make a successful case for proportionate action on climate change. Yet, astonishingly, there has never been an internationally mandated global assessment of climate change risks.

Global climate assessments made by the Intergovernmental Panel on Climate Change (IPCC) have played and continue to play a crucial role in assessing the evidence about climate change. But their main focus has been on what is known with the greatest confidence. A climate risk assessment is different -- it makes clear the scale and severity of risks to inform judgements about the priority to be given to avoiding or mitigating them[1].

Many countries have undertaken their own climate risk assessments primarily to inform policies and planning for adaptation. Other studies have demonstrated a risk assessment approach[2] or assessed specific categories of risk, such as economic threats[3] or geopolitical instabilities arising from climate change[4]. But these have had limited reach.

Only a global risk assessment, led by an appropriate international institution and designed to make clear the full scale of the global threat, can explore the full range of outcomes that global emissions reductions could avoid.

Here we call for such a global climate risk assessment and outline how to go about it.

Identify worst-case scenarios

The principles for producing risk assessments are well established in fields such as public health, engineering, defence and intelligence. They include: identifying risks in relation to objectives; focusing on the largest risks including 'plausible worstcase' scenarios (in the long term as well as near term); using the best available information; considering the full range of possibilities (with probabilities where they can be quantified and qualitative information where they cannot); taking a holistic view; and being explicit about value judgments and limitations in the evidence[2].

These principles lead to a practical difference between a prediction and a risk assessment. A prediction asks first 'what is expected to happen?' and then 'how might that affect society's interests?' A risk assessment asks first 'what could happen that would adversely affect society's interests?' and then 'how likely are these outcomes?' Since climate change risks increase over time, this last question becomes 'how does the likelihood of adverse outcomes change as a function of time and of human actions?'

Crucially, a risk assessment does not provide a counsel of despair. Instead, it provides a clear picture of the outcomes that societies can still choose to avoid. A global climate change risk assessment would support the development of timely measures for climate change mitigation and highlight the extent of human agency.

Overcome challenges

Producing a global climate change risk assessment is feasible, if the following scientific, societal and institutional challenges are addressed.

Assessing likelihoods. Considering the likelihood of rare events, particularly worst-case scenarios, is a major challenge for risk assessments. Extreme events that might never have been seen before, like the collapse of an ice sheet, are hard to predict and depend on sensitive yet poorly understood processes, such as links between different causes of ice sheet instability[5].

Risk assessments can handle such uncertainties by focussing only on the most important information. For climate change, this means identifying a threshold of impact severity – such as 5 metres of sea level rise --- and assessing the likelihood of crossing this threshold as a function of time[6]. Uncertainties remain, but by keeping the focus of the analysis on what matters most, the scale of the risk can be clearly communicated and understood. (see graphic 1)

Cascades of related risks are also difficult to assess. For example, food systems will be affected by a combination of changes to soils, pollinators and diseases as well as heat, drought and flooding. Economic growth and geopolitical stability will be affected by shortages of resources, loss of land, reduced productivity and the impacts of extreme weather on critical infrastructure. All these risks interact with and compound one another[7,8,9]. (See graphic 2). These can be handled successfully by harnessing new methodologies[10,11] and different risk assessment communities (eg in healthcare, security, finance and environment).

Reflecting wide perspectives. The broad nature of risk assessments means they are hard to produce. First, they are interdisciplinary. For example, the expertise necessary to identify a societally relevant threshold of impact (such as mass casualties in a city from extreme heat which needs socio economic and health information) differs from that needed to assess the likelihood of crossing that threshold (which needs climate modelling information). Experts and practitioners from different fields must thus work together.

Second, assessments must consider societal objectives that are subjective and values driven. Widely recognised priorities regarding human, environmental and economic security would provide a sufficient basis for the risk assessment we are proposing. Also, policy makers can find it difficult to identify the 'worst-case' outcomes that they wish to avoid if they lack information about the full range of possible outcomes**.** Dialogue between scientists and decision-makers can overcome these challenges.

And third, attitudes to risk and uncertainty vary. Whereas scientists tend to worry a lot about avoiding false alarms, risk management practitioners are more concerned with not missing devastating events. Involving experts from fields where risk is central to decision-making, such as public health or national security, would help a climate change risk assessment achieve a balance between being overly cautious and overly alarmist.

Achieving high level backing. A strong institutional basis for a risk assessment is crucial for its success. A global climate change risk assessment should therefore report to the highest levels of government, since it is only there that the priority to be given to addressing climate change relative to other societal objectives can be decided. Implementation through international institutions, supported by relevant regional, national and expert bodies, would provide the authority needed for the assessment to have the necessary impact worldwide.

Practical steps

One way to move forward might be for the United Nations Secretary General to appoint a climate risk advisory council. This panel could be tasked with carrying out the risk assessment and could be funded by national governments that support the initiative. This approach could be flexible and fast.

Alternatively, one or a group of international organisations such as the International Science Council, the World Meteorological Organization, or the International Network for Governmental Science Advice could take a lead.

Such an effort would ideally involve other expert organisations that represent key dimensions of climate risk, such as the World Health Organisation (health), the World Food Programme (food security) the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (nature) and the International Monetary Fund (macroeconomic stability).

Whichever mechanism is chosen, a first risk assessment needs to be co-developed quickly with the relevant users. It can be illustrative and need not be comprehensive but it should focus on climate risks whose impacts are expected to be most severe such as mass heat-related deaths and large-scale inundation. An effective public communication plan is vital for public accountability.

Longer term, the assessment can be updated on a regular cycle, such as every five years, in line with standard practice for national risk assessments and climate science assessments, building iteratively on lessons learned. Future assessments can be strengthened through targeted research designed to inform risk analysis, including deeper investigation of impact thresholds and cascading failures in interconnected human and natural systems.

Humanity still has the opportunity to avoid the worst impacts of climate change and shape a more prosperous, liveable future. A global assessment of avoidable climate change risks would enable political leaders and citizens to fully understand what is at stake and motivate us all to seize that opportunity while we still have it.

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GRAPHIC INCLUDED IN ARTICLE (Panel descriptors and callouts still being edited with Nature who will also redraw this graphic based on the raw data we have sent them)

CLIMATE RISKS TO AVOID

Exploring the chances of worst-case scenarios enables governments and others to plan to avoid the greatest threats.

Panel A
Cities flooded by rising seas
By 2200, more than 10m of sea level rise would overtop London's flood defences. This would triple the area vulnerable to severe coastal floods, place millions more people at risk and make parts of the city uninhabitable.

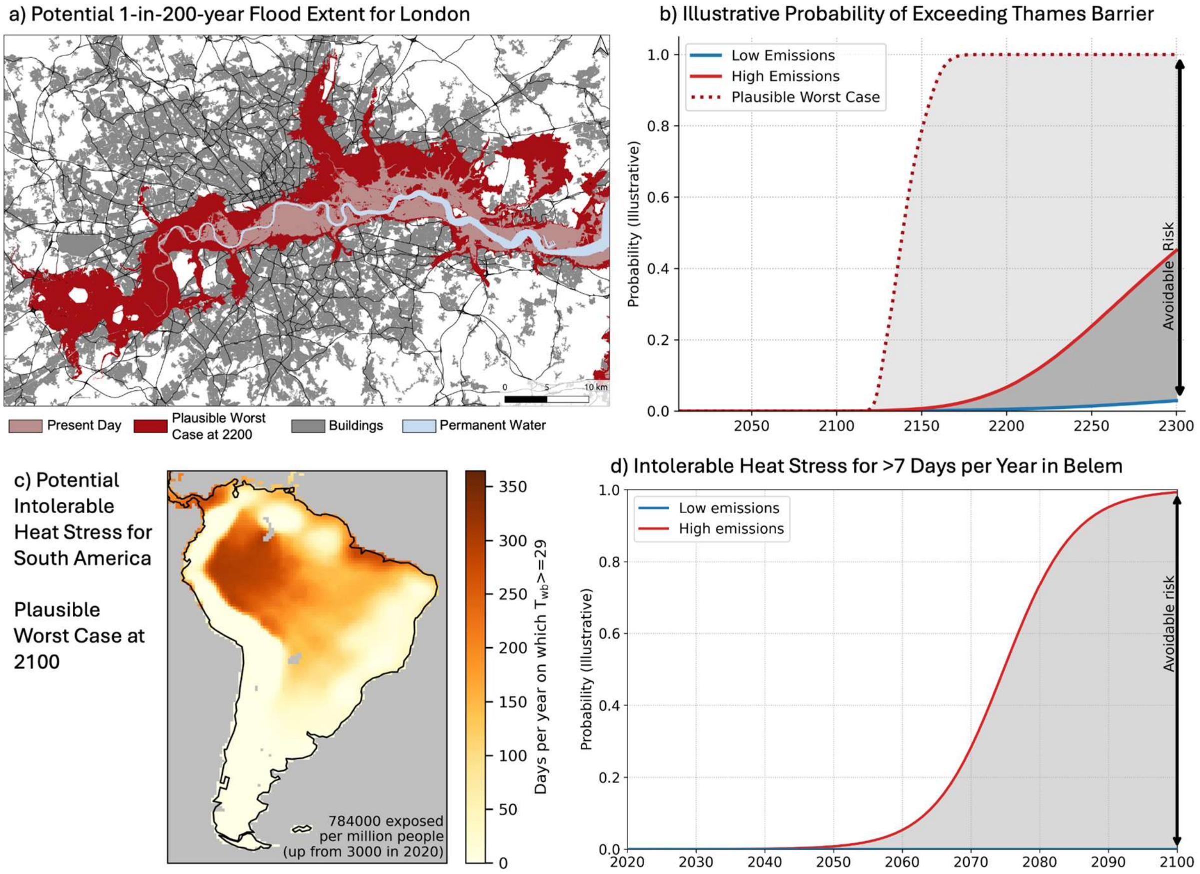
Callouts:
Panel b)

- Seas could breach London's flood defences by 2170, if emissions continue.

Panel C
Intolerable heat stress
By 2100, millions of people in South America risk being exposed to levels of humid heat beyond human tolerance on hundreds of days per year.

Callout panel d) pointing to worst case:

Under high emissions, 3 out of 4 people in South America will face intolerable humid heat by 2100, up from just 1 in 300 today.


a) Potential 1-in-200-year Flood Extent for London
0
5
10 km
Present Day
Plausible Worst Case at 2200
Buildings
Permanent Water
b) Illustrative Probability of Exceeding Thames Barrier
Low Emissions
High Emissions
Plausible Worst Case
Probability (Illustrative)
Avoidable Risk
1.0
0.8
0.6
0.4
0.2
0.0
2050
2100
2150
2200
2250
2300
c) Potential Intolerable Heat Stress for South America
Plausible Worst Case at 2100
784000 exposed per million people (up from 3000 in 2020)
Days per year on which T_{wb}>=29
350
300
250
200
150
100
50
0
d) Intolerable Heat Stress for >7 Days per Year in Belem
Low emissions
High emissions
Probability (Illustrative)
Avoidable risk
1.0
0.8
0.6
0.4
0.2
0.0
2020
2030
2040
2050
2060
2070
2080
2090
2100

SUPPLEMENTARY INFO This will go in a separate file and be attached to the main article as a pdf.

An approach consistent with the principles of risk assessment is to identify a threshold of impact severity, and assess the likelihood of this threshold being crossed as a function either of time or of time-dependent variables such as global average surface temperature or sea level (Sharpe, 2019). In this way, events or conditions that are first observed in the tail of the distribution are seen to pass through the centre of the distribution. Uncertainties remain, but their presence does not prevent communication of the relevant information. When a 'worst case' outcome is shown to become likely, the scale of the risk can be clearly understood. We illustrate this approach in ***Box 1***.

Another scientific challenge is presented by the complexity of climate risk cascades. Many of the risks to human well-being are direct, such as the health impacts from heatwaves, wildfires or flooding. But the largest risks may be indirect, arising from the combination of many factors. For example, the risk of climate change to food systems arises from factors including soil damage, pollinator loss, and animal disease, as well as the effects of extreme heat, drought and flooding on crop and livestock production. Similarly, economic growth and geopolitical stability may be affected by resource shortages, loss of land, and reduced productivity, as well as by the effect of extreme weather events on critical infrastructure. All these risks interact with and compound one another (Lawrence et al, 2020; Ranger & Oliver, 2024; IPBES, 2019). We illustrate this in ***Box 2***.

Box 1. Example risks from sea level rise and increased humid heat stress. Sea-level rise poses a huge societal risk in the coming centuries for coastal and low-lying areas. A plausible worst case scenario based on plausible ice sheet instability mechanisms, would threaten the viability of London by 2150, by pushing local sea level rise beyond the suggested 5 m adaptation limit for flood defences (Ranger et al, 2013). By 2200, the same scenario leads to more than 10 m of sea level rise with a 200% increase in flood risk area and more than 2 million additional people in London exposed to flood hazard, based on 2025 population data (see Figure 1 panel a). At only 3 m of sea level rise, London would require a new tidal barrage system. The risk of exceeding this threshold in the coming centuries can be reduced substantially through mitigation (panel b). Heat stress represents a direct threat to human health. By 2100, millions of people in South America risk being exposed to humid heat conditions exceeding human thermoregulation limits (wet-bulb temperatures exceeding 29 °C) on hundreds of days per year, with over 3 out of every 4 people affected under a plausible worst case scenario, compared to less than 1 out of every 300 today (panel c). In Belém, Brazil, the probability of experiencing more than seven days per year of such humid heat stress remains near zero throughout the century under low emissions, but it rises sharply from mid-century onward under high emissions (panel d). Note that for both sea level rise and heat stress, precise probabilities cannot currently be robustly quantified.

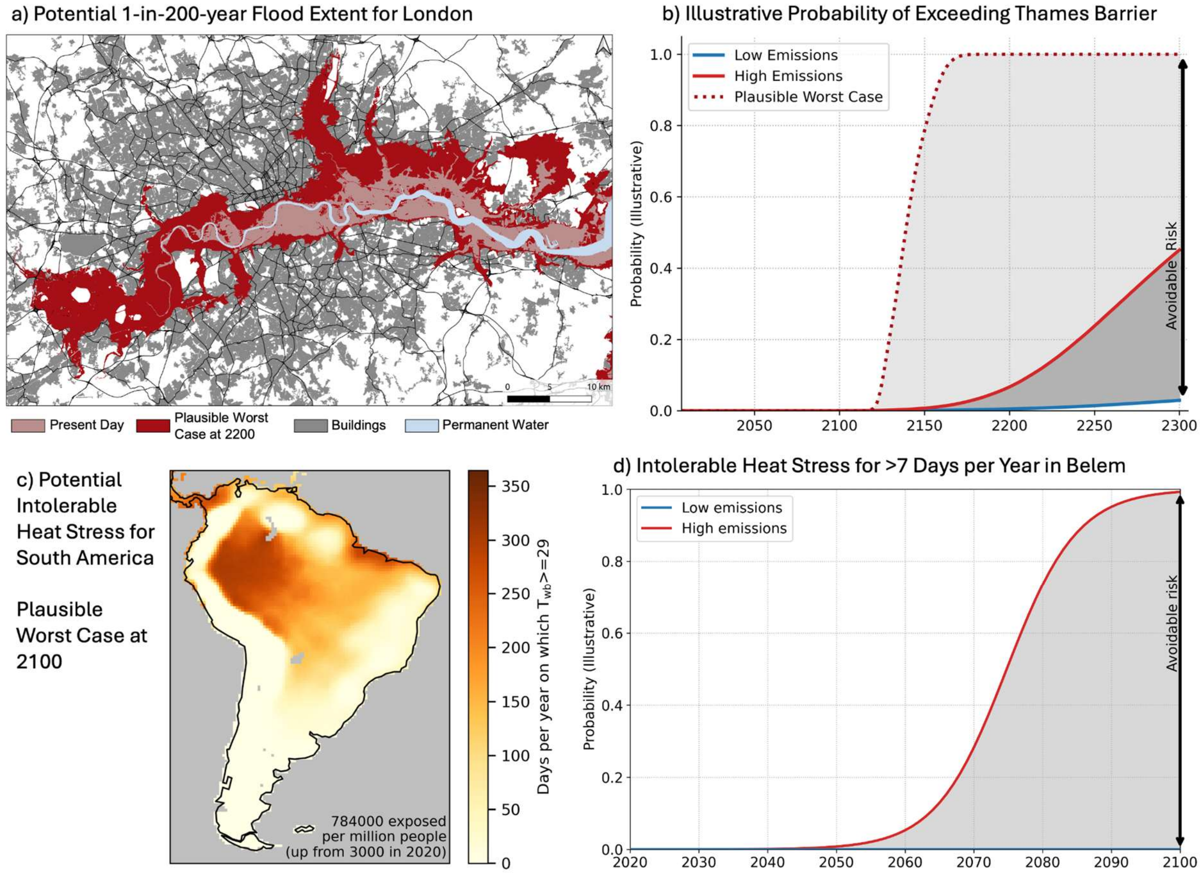


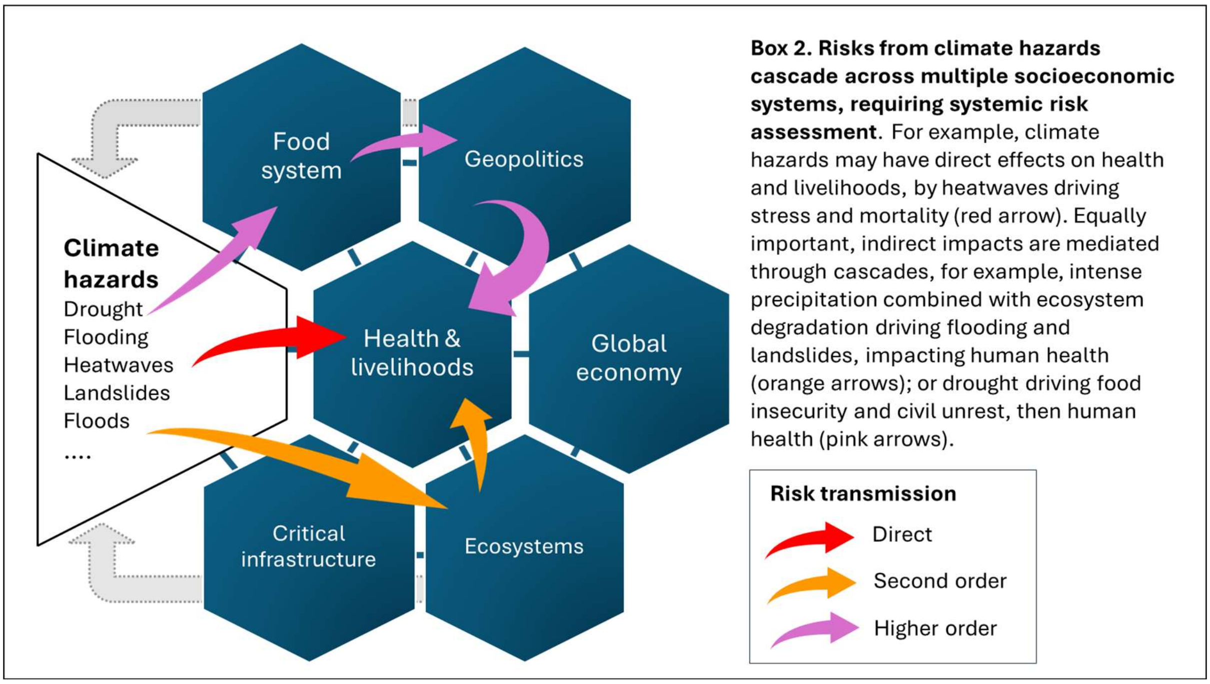
Figure 1: a) A comparison of the 1-in-200-year storm surge (the basis of current UK flood defences) coastal flood inundation map for the present day and for a plausible worst case scenario at 2200 (Palmer et al, 2024; their Story H2), in the absence of coastal flood defences. The simulations illustrate the areas at risk should existing/future flood defences fail or if adaptation limits are reached. b) Illustrative probabilities of exceeding the adaptation limits for the current Thames Barrier flood defence system under low emissions, high emissions and a plausible worst case scenario. c) Number of days a year on which South America experiences intolerable heat stress in a plausible worst case scenario in 2100. d) Illustrative probabilities of exceeding intolerable

humid heat stress for more than 7 days per year in Belem, Brazil, under low and high emissions scenarios.

Methods details for Figure 1:
Panel a) combines the Palmer et al (2024) sea level rise Storyline H2 at 2200 with the UK Environment Agency Coastal Flood Boundary Conditions using the Fathom UK flood inundation model described by Bates et al. (2023). Since future defence standards are unknown, the simulations do not include coastal defences so that a consistent approach can be taken across both present day and 2200. The results can be interpreted as characterising the area at risk should current/future flood defences fail or if adaptation limits are reached under future sea level rise. All flood model simulations were conducted by James Savage. Panel b) provides illustrative probabilities of crossing the 3.0 m peak water level threshold, which represents the adaptation limit of the current Thames Barrier flood defence system (Ranger et al, 2013). The 3.0 m threshold assumes a 0.5 m contribution from increased storm surge heights and a 2.5 m contribution from mean sea level rise. The probabilities are computed directly from the 450,000 member Monte Carlo simulations for global mean sea level (GMSL) documented in Palmer et al (2020; 2024), assuming that GMSL is a good first-order approximation to the local rise at London - as evidenced in Palmer et al (2024) and elsewhere. “Low Emissions” and “High Emissions” correspond to the RCP2.6/SSP1-2.6 and SSP3-7.0 scenarios, respectively (Meinshausen et al, 2011; O’Neill et al, 2014). The “Plausible Worst Case” scenario uses the simulations of DeConto et al (2021) for the Antarctica contribution to future sea level rise, which results in much larger rates post-2100 from Marine Ice Cliff Instability processes (DeConto and Pollard, 2016). The “High Emissions” and “Plausible Worst Case” results use Monte Carlo simulations performed under RCP8.5 and then scaled down to approximate SSP3-7.0 based on the ratio of global mean sea level rise at 2150 between SSP3-7.0 and SSP5-8.5 reported in the IPCC Sixth Assessment Report of Working Group I (Fox-Kemper et al, 2021).

Panel c) shows the annual exceedance (days per year) of intolerable heat stress, defined here as daily maximum wet bulb temperature being equal to or above 29 °C (the mid-point of a published 26 to 31 °C range; Meade et al., 2025). A plausible worst case is illustrated here by a scenario approximately equivalent to SSP3-7.0 in UKESM1-0-LL, a CMIP6 model with a high-end transient climate response (TCR = 2.72; Nijsse et al., 2020). Population exposure is based on the equivalent shared socioeconomic pathway. Panel d) provides illustrative probabilities of reaching or exceeding 29 °C wet bulb temperature in Belem, Brazil, for at least seven days a year from 2020 to the end of this century. The probabilities are estimated from an assumed normal distribution of exceedances for each year, based on a mean value from a mid-range CMIP6 model (CNRM-ESM2-1, TCR = 1.92; Nijsse et al., 2020), a minimum from a low-end model (INM-CM4-8, TCR = 1.32), and a maximum from a high-end model (UKESM1-0-LL). “Low Emissions” and “High Emissions” here are represented by the same scenarios as panels a) and b) above.

Box 2



Box 2. Risks from climate hazards cascade across multiple socioeconomic systems, requiring systemic risk assessment. For example, climate hazards may have direct effects on health and livelihoods, by heatwaves driving stress and mortality (red arrow). Equally important, indirect impacts are mediated through cascades, for example, intense precipitation combined with ecosystem degradation driving flooding and landslides, impacting human health (orange arrows); or drought driving food insecurity and civil unrest, then human health (pink arrows).

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