# 10 NEW INSIGHTS IN CLIMATE SCIENCE

## 2024/2025

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Each year, Future Earth, The Earth League and the World Climate Research Programme gather leading scholars from around the world to review the most pressing findings in climate research. The result is the *10 New Insights in Climate Science*, delivered as two self-standing products: a peer-reviewed scientific article and this policy report providing a rich and valuable synthesis for policymakers and society at large. The scientific evidence underpinning this year's report was published between January 2023 and June 2024.

For policymakers responding to the urgent challenge of the climate crisis, the *10 New Insights in Climate Science 2024/2025* offers credible guidance through 2025 and beyond.

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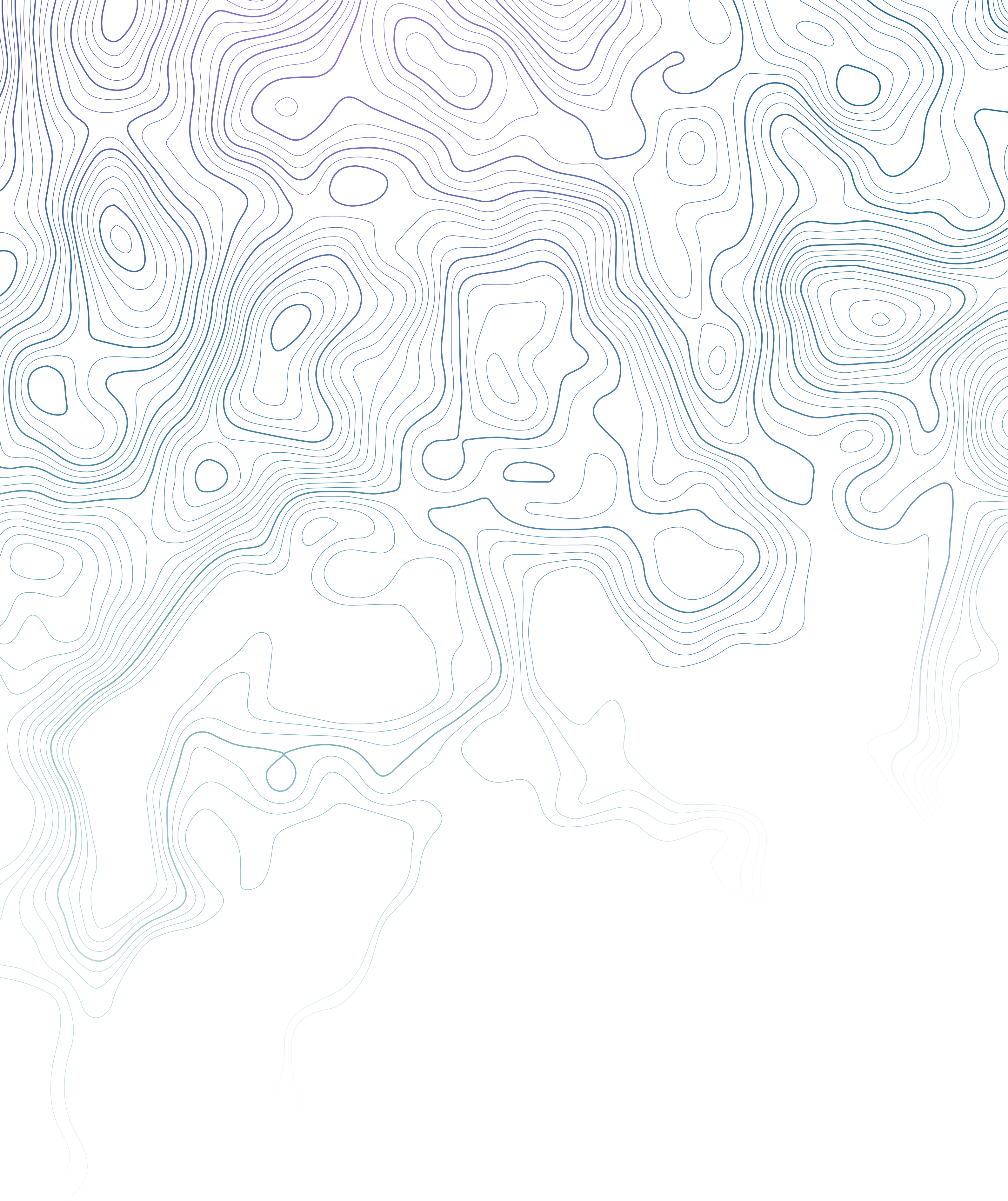

# INSIGHTS AT A GLANCE

# INSIGHTS AT A GLANCE

1. **Methane levels are surging. Enforceable policies for emission reductions are essential.** Methane levels have surged since 2006, driven primarily by human activities. We have enough information about our methane emissions to take action, but more enforceable policies to drive reductions are vital. While reductions in the fossil fuel and waste sectors are most feasible, addressing agricultural emissions is also critical. Climate warming is increasing natural methane emissions, making rapid cuts to human-caused emissions more urgent.

2. **Reductions in air pollution have implications for mitigation and adaptation given complex aerosol-climate interactions.** Reductions in air pollution have greatly improved public health, but simultaneously have revealed the full extent of warming caused by historical greenhouse gas emissions, and have additional regional implications on rainfall and extreme events. Mitigation and adaptation strategies cannot afford to ignore aerosol–climate interactions.

3. **Increasing heat is making more of the planet uninhabitable.** Rising heat and humidity are pushing more people outside of habitable climatic conditions, with over 600 million already affected and many more at risk as warming continues. Heat action plans, early warning systems, and targeted measures for vulnerable groups are a priority for adaptation in the most affected regions.

4. **Climate extremes are harming maternal and reproductive well-being.** Climate change is increasing risks for pregnant women, unborn children and infants, threatening decades of progress in maternal and reproductive health (MRH). These impacts are exacerbated in contexts with high levels of poverty and entrenched gender norms. Effective interventions should be integrated with broader efforts to advance gender equity and climate justice.

5. **Concerns about El Niño-Southern Oscillation and the Atlantic Meridional Overturning Circulation with an increasingly warm ocean.** Unprecedented ocean warming since 2023 has heightened concerns about large-scale ocean and atmosphere interactions. New research highlights the risk of more extreme and costly El Niño events under climate change, and even the threat to the stability of the Atlantic Meridional Overturning Circulation (AMOC), with far-reaching implications for climate and societies.

6. **Biocultural diversity can bolster the Amazon's resilience against climate change.** The Amazon faces growing threats from climate change and deforestation, pushing the rainforest closer to critical thresholds and increasing the risk of large-scale collapse. Regional and local actions to safeguard ecological and biocultural diversity can strengthen the forest's resilience to climate change. However, these efforts will be insufficient to safeguard the Amazon unless global emissions rapidly decline.

7. **Critical infrastructure is increasingly exposed to climate hazards, with risk of cascading disruption across interconnected networks.** Critical infrastructure underpinning the functioning of all societies is increasingly vulnerable to more frequent and intense climate hazards, with interconnected systems posing a risk of cascade effects. Artificial intelligence (AI) tools can enhance the resilience of critical infrastructure to climate change.

8. **New frameworks for climate-resilient development in cities provide decision-makers with ideas for unlocking co-benefits.** Few cities have effectively integrated mitigation and adaptation strategies in their climate action plans. A social-ecological-technological systems (SETS) approach can help guide climate-resilient development by maximising co-benefits and minimising trade-offs through strategies tailored to the unique contexts of each city.

9. **Closing governance gaps in the energy transition minerals global value chain is crucial for a just and equitable energy transition.** As demand for energy transition minerals (ETMs) grows, supply chain risks, geopolitical tensions, and socio-environmental impacts concentrated in the Global South are expected to intensify. A just transition that avoids greater burdens and fewer benefits for Global South countries is a major governance challenge.

10. **Public's acceptance of (or resistance to) climate policies crucially depends on perceptions of fairness.** Perceived fairness is a key determinant for public acceptance of climate policies. Ignoring citizens' concerns undermines the effectiveness of climate action and fuels resistance. Participatory decision-making and clearly communicated revenue-use plans can help navigate the structural socio-economic factors that generate resistance to climate policies.

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# INTRODUCTION

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The years 2023 and 2024 have shattered global temperature records. Last year was the warmest year on record, with a global average of 1.45°C (± 0.12°C) warmer than the 1850–1900 pre-industrial level.[1] This trend has continued into 2024,[2] with each month from June 2023 to June 2024 setting a new average temperature record for the respective month. Global sea surface temperatures set new records for 14 consecutive months (April 2023–May 2024). In August 2024 the global temperature soared 1.51°C above pre-industrial levels. It is highly probable that 2024 will become the warmest year on record. This level of warming and human-induced climate change has fuelled a series of extreme weather events worldwide, making them more likely and intense.[3] Examples include Canada's most extensive wildfire season on record (twice as likely), the deadly heatwaves across South and South-East Asia (30 times more likely), and the extreme rainfall in the Mediterranean region that caused devastating floods in Libya (up to 50 times more likely and up to 50% intense).

The first Global Stocktake (GST), a comprehensive assessment of progress on the Paris Agreement, was finalised last year at COP28 in Dubai. Its main conclusion is that the world is significantly off-track in meeting the Paris Agreement's goal of limiting long-term warming to 1.5°C. The GST called for a transition away from fossil fuels in energy systems, as well as setting important agreed-upon global goals to triple renewable energy capacity and double the rate of energy efficiency improvements by 2030. However, it also included provisions that leave room for continued use of some fossil fuels, and it lacked a timeline for phasing out fossil fuels across all sectors. To limit long-term warming to below 2°C, global emissions by 2030 must be 28% lower than the levels projected under current policies. Limiting warming to 1.5°C requires a much more ambitious reduction of 42%.[4]

1 United in Science 2024. Compiled by the World Meteorological Organization (WMO): https://library.wmo.int/idurl/4/69018

2 EU Copernicus Climate Change Service: https://climate.copernicus.eu/climate-bulletins

3 World Weather Attribution: https://www.worldweatherattribution.org

4 Emissions Gap Report 2023. UNEP: https://doi.org/10.59117/20.500.11822/43922

At COP28 there was also progress on adaptation, with the adoption of the UAE Framework for Global Climate Resilience (FGCR), which elaborates on and operationalises the Global Goal on Adaptation (GGA). Similarly, there was progress on the operationalisation of the Loss and Damage Fund (LDF). However, the FGCR lacks specific, measurable indicators, and much remains to be solved regarding the funding and framework for implementation of the LDF. The current adaptation finance gap is estimated at US$194–366 billion per year, and is widening due to faltering financial flows and increasing adaptation needs.[5] COP29 in Baku, Azerbaijan, is expected to have a major focus on climate finance, with the adoption of the New Collective Quantified Goal (NCQG) as the top priority. A successful COP29 will be one that makes significant progress towards unlocking climate finance at scale. This would enable greater ambition on mitigation and adaptation targets in the new Nationally Determined Contributions (NDCs) due in February 2025.

The *10 New Insights in Climate Change*, jointly produced by Future Earth, The Earth League and the World Climate Research Programme, is an annual series that highlights key recent advances in climate change research across the natural and social sciences. Leveraging the global and diverse research networks of the partner organisations, the report gathers expert input on recent advances in climate change research to present a prioritised set of Insights. These Insights are a timely and succinct resource to help policymakers and negotiators in the United Nations Framework Convention on Climate Change (UNFCCC) process stay informed about the latest developments across various fields of climate change research. It is important to note that this is not a "top 10" list; the selection aims to reflect the thematic breadth of climate change research, and the ordering of the Insights does not indicate their relative importance. Finally, the title includes the years 2024–2025 to acknowledge that while the peer-reviewed research underpinning the Insights was published in 2023–2024, the relevance of the policy implications extends well beyond this timeframe.

5 Adaptation Gap Report 2023. UNEP: https://doi.org/10.59117/20.500.11822/43796

The first two insights of this year's report highlight recent changes in two kinds of emissions from human activities that have direct implications in the near term for global warming and regional climate. First, atmospheric methane levels have surged in the past two decades, tracking warming scenarios of 3°C or more, largely driven by emissions from human activities (Insight 1). Given methane's higher potency and shorter atmospheric lifetime, reducing these emissions with existing technologies is one of the fastest and most effective levers for limiting near-term warming. But we are not yet seeing the emissions reductions that have been pledged, largely due to a lack of enforceable policy. Atmospheric aerosol loading, on the other hand, is declining in some regions due to effective policies aimed at improving air quality (Insight 2). While this is a very positive trend in terms of human health, it poses some short-term challenges regarding climate change, given the net cooling effect of some aerosols and their regionally differentiated impacts on rainfall and extreme weather events. These insights highlight the need for comprehensive mitigation planning strategies that consider multiple pollutants and their interactions, as well as comprehensive climate risk assessments, in the case of aerosols, to inform adaptation planning.

Hundreds of millions of people find themselves living under climate conditions outside what is considered the historical range of habitability, and the exposed population will continue to grow as warming continues (Insight 3). This is now an undeniable priority for adaptation planning, particularly in lower-income countries in tropical regions. Adaptation measures should include specific provisions for different vulnerable groups. Evidence has been accumulating rapidly on the specific impacts of climate change, especially of heat extremes, on pregnant women and newborn infants (Insight 4). Early warning systems are a priority area for regional cooperation, in connection with heat preparedness plans at national and subnational levels. Extreme heat affects human health and livelihoods, as well as ecosystems and infrastructure, and has ripple effects across the economy. Climate change appears to be making El Niño events more intense, which could potentially generate additional global economic costs to the tune of tens of trillions of US dollars by the end of the century (Insight 5). We highlight how climate hazards can disrupt critical infrastructure, the vulnerability of increasingly interconnected networks, and approaches to increasing their resilience (Insight 7). The development and implementation of robust adaptation measures across the Global South will largely depend on substantial increases in the climate finance devoted to adaptation.

The gradual increase in average (and extreme) temperatures that follows from the continued accumulation of greenhouse gases (GHG) in the atmosphere pose grave challenges to societies. But the challenges that would come from the disruption of key geophysical processes that operate at regional to planetary scale would be of a significantly higher order. Recent publications about the Atlantic Meridional Overturning Circulation (AMOC) document the slowdown and suggest the possibility of collapse much sooner than previously estimated (Insight 5). Such an event would have truly catastrophic consequences for our societies, particularly through its effects on regional temperatures and precipitation patterns. Similarly, the resilience of the Amazon rainforest is being eroded, increasing the risk of large-scale collapse. Protecting and restoring the Amazon's ecological and biocultural diversity is vital for strengthening the forests' resilience and in turn maintaining the regional water recycling process (Insight 6). However, the rapid reduction in GHG emissions is indispensable to safeguard the stability of these Earth system processes.

The final set of insights are related to just transitions and climate-resilient development (CRD). Cities are central nodes for climate action, both to mitigate their outsized impact footprint, and to adapt to the changing climate for their growing share of the population. Planning for CRD requires a holistic, systems approach that can be tailored to diverse socio-economic and environmental conditions (Insight 8). As cities strive to reduce their GHG footprint and enhance their resilience, the "just transition" imperative means they must pay attention to the sourcing and use of energy transition minerals (ETMs), which are crucial for clean energy technologies. The demand for ETMs has been growing rapidly as the world starts moving away from fossil fuels. Improvements in the governance of ETM value chains will be necessary for the transition to be truly global and just (Insight 9). At the national and subnational level, the implementation of climate and energy policies must also address the challenge of gaining citizen acceptance or at least not generating entrenched resistance. Whether or not a policy is perceived as fair strongly influences its acceptance by, or resistance from, the citizens (Insight 10). This is crucial for effective policy design and implementation, and points to the importance of understanding the political-economic context that fosters either acceptance or resistance.

We hope that the *10 New Insights in Climate Science 2024/2025* will reach party delegations attending COP29 in Baku, Azerbaijan, helping inform their positions and arguments, and ultimately being reflected in the final outcomes of the negotiation, including:

- Concrete financial commitments to significantly increase heat adaptation measures, especially for vulnerable populations, and support the global implementation of comprehensive early warning systems. Progress on the inclusion of specific, measurable indicators within the Framework for Global Climate Resilience (FGCR) focused on heat stress.

- A formal decision encouraging all parties to incorporate explicit, quantifiable methane reduction targets in the NDCs, with a support mechanism to assist countries in developing these targets and action plans. Additionally, a focused initiative and/or specialised task force to provide recommendations for integrating aerosol considerations into future NDCs would be a very positive step towards more comprehensive climate action plans.

- Strengthening and refinement of the Just Transition Work Programme (JTWP) framework, with specific provisions to strengthen governance efforts so that the sourcing and management of ETMs align with just transition principles, emphasising equity, sustainability, and benefit-sharing across the entire value chain. This could include guidance for cities to follow these principles as they implement climate-resilient development strategies.

- The establishment of a robust New Collective Quantified Goal (NCQG) on climate finance, coupled with a clear framework for countries to close the ambition and implementation gaps, should set the stage for a major step-up of climate action between COP29 and COP30.

The science underpinning each of the Insights presented in this report is described in more detail and with all the supporting references in: Schaeffer, R., Schipper, E.L.F., et al. (2024). *Ten New Insights in Climate Science 2024*. Available at 10insightsclimate.science.

10 NEW INSIGHTS IN CLIMATE SCIENCE

# THE INSIGHTS

# 1 Methane levels are surging. Enforceable policies for emission reductions are essential

**KEY MESSAGES**

- **Atmospheric methane levels have grown substantially since 2006, mainly due to rising emissions from human sources. Growing emissions of methane from fossil fuels, livestock and waste are the main drivers, followed by more variable natural sources.**
- **Cuts to emissions from fossil fuels and waste management industries are most feasible to mitigate rising methane levels. The agricultural sector, although harder to reform, also has significant reduction potential.**
- **There has also been a growth in natural methane emissions due to climate-driven feedbacks. Without rapid action to curb greenhouse gas emissions from human sources, these natural sources of methane – such as wetlands – are likely to continue to grow, requiring greater reductions from human activities.**
- **We have enough information about methane emissions to take action, but enforceable policies to drive reductions are vital.**

It may be short-lived but methane is a potent greenhouse gas, with rising emissions of methane accounting for an increase of 0.5°C in average global temperatures since the late 1800s. Following a plateau in the early 2000s, atmospheric methane levels have resumed growth since 2006, with the last five years seeing the fastest rise ever since records began. Rapid and deep cuts in methane emissions from human activities are vital, alongside efforts to curb carbon dioxide emissions, in order to limit warming within the Paris Agreement goals.

Understanding the main factors behind the recent rise in methane levels is crucial for developing an adequate mitigation strategy. Evidence points to increasing emissions from human activities, likely from livestock and waste emissions followed by fossil fuel production and use as primary contributors, as well as reductions in methane's atmospheric removal and a rise in emissions from tropical wetlands. In the decade from 2010, methane from human sources accounted for around two-thirds of total methane emissions. There are still large uncertainties about those sources, with different models and monitoring efforts providing different results, though estimates for categories of sources and sinks generally co-incide. Satellite capabilities have improved under-standing of methane sources over large areas and can detect large emissions from individual industrial facilities, such as coal mines, oil and gas production facilities, and gas pipelines. Alongside modelling efforts and expanded air sampling for methane isotope analysis, this helps to provide a clearer picture of emissions from various sources, including landfills, rice paddies and livestock, allowing for better designs and strategies to reduce methane emissions.

Deep cuts to methane emissions from fossil fuel and waste management industries are the most feasible, and many solutions are cost-effective as well, since they improve efficiencies and use existing technologies. In the fossil fuel sector, a relatively small number of large, intermittent sources have

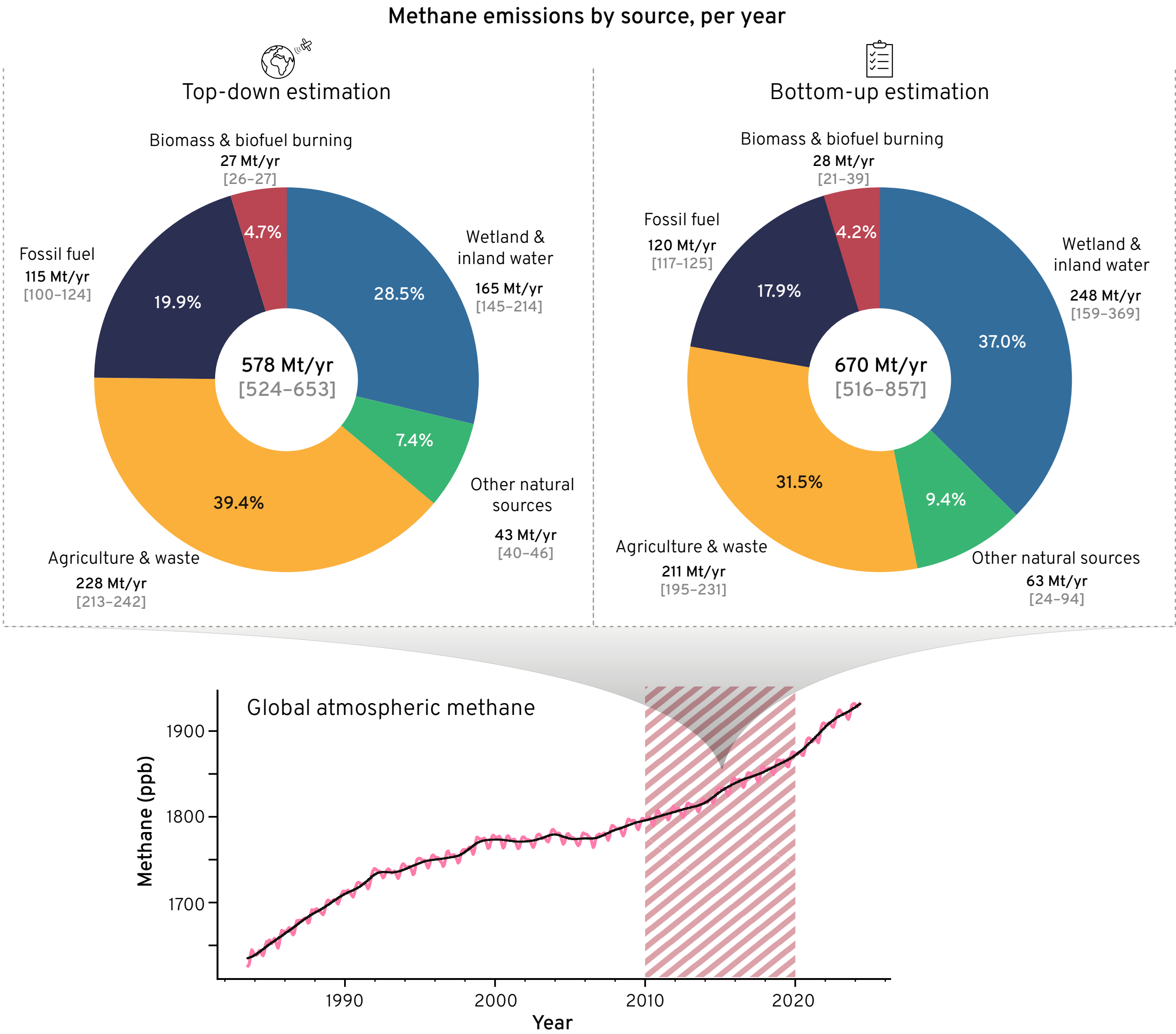


**Figure 1. Annual methane emissions by source (average for the period 2010–2019).** Estimated based on top-down integrative methods (top-left) and bottom-up integrative methods (top-right). Uncertainty ranges are indicated in square brackets. Data adapted from Saunois et al. (2024). Bottom: Trends 1983–2024 in global atmospheric methane (NOAA); shaded area indicates decade over which emissions sources are attributed.

an outsized impact on total emissions. Clusters of large emissions from oil and gas facilities and gas pipelines, as well as coal mining, have been observed around the world, including published detected methane plumes in Algeria, China, Kazakhstan, Russia, Turkmenistan and the US, often exhibiting emissions of tens of tonnes an hour. Persistent emissions have also been detected from urban solid waste facilities around the world, for example in Buenos Aires, Delhi, Lahore and Mumbai, with emissions in the range of 3 to 29 tonnes per hour. The agricultural sector is the largest methane source from human activities (Figure 1) and is tougher to tackle, though there are options. Mitigations include the use of lower-emitting livestock feeds, manure management, diet changes away from farmed meat, and reduction in food waste. While technologies are emerging for methane removal, or to oxidise it to $CO_2$, these are in the early stages and would require significant development, scaling and incentivisation to be cost-effective.

Looking at emissions from natural systems, a global rise of 4–6% from the 2000s to the 2010s is estimated from multiple lines of evidence, with increases particularly from tropical wetlands. Temperate and Arctic regions may also be experiencing increases, but there is not yet sufficient evidence to determine trends. Natural sources of methane are hard to control, so if they continue to grow, deeper cuts to greenhouse gas emissions from human sources will be needed. Globally, climate feedback mechanisms are expected to further amplify emissions from natural systems, yet many Earth system and integrated assessment models do not yet include these feedbacks, or have significant uncertainties in how they represent methane sources. This could mean that their future emissions in a warming world are underestimated, a risk that should be accounted for in comprehensive mitigation scenarios.

We have enough information about the sources of methane, and sufficient monitoring capacity, to take action quickly and effectively. Methane emissions reductions are tractable and have been demonstrated, but with only 13% of methane emissions currently covered by mitigation policies, stronger and more consistent action is needed to reverse the trend in atmospheric methane. The Global Methane Pledge (GMP), signed by 158 country participants, has a clear target of a 30% reduction in methane emissions from 2020 levels by 2030. This voluntary initiative has pushed the institutionalisation of methane reporting forward, but progress on implementation is urgently needed for fulfilling the GMP target and the Paris Agreement goals.

**POLICY IMPLICATIONS**

- Rising levels of atmospheric methane are directly at odds with the reductions needed to meet the Paris Agreement goals. Emissions from human activities must decrease significantly in the near term. A large portion of these reductions is feasible through the deployment of existing technologies, particularly in the fossil fuel and waste sectors, many of which are low-cost.

- The Global Methane Pledge (GMP) signalled collective momentum to address methane emissions. However, only 13% of methane emissions are currently covered by mitigation policies. Positive legal developments include a U.S. Environmental Protection Agency rule and the 2024 EU regulation on methane emissions in the energy sector. Similar enforceable regulations and pricing mechanisms should be promoted across other regions, and for other economic sectors.

- Continued investment in enhanced monitoring and transparent reporting mechanisms is needed to focus efforts and track progress. The International Methane Emissions Observatory (IMEO) plays a key role serving as a core implementing partner of the GMP.

- At COP29 the Mitigation Work Programme (MWP) could prioritise methane in line with its mandate on near-term climate action and urgent implementation. Specifically, the MWP can raise awareness, facilitate the sharing of mitigation tools and solutions, and build momentum for broader adoption and scaling of successful approaches. The IPCC-AR7 Methodology Report on Short-lived Climate Forcers expected in 2027 will provide essential guidance on this matter.

- The next round of Nationally Determined Contributions (NDCs) should address methane emissions separately through the complementary Methane Action Plans, with sector-specific targets and strategies to increase transparency and ambition. Positive developments in this regard include the COP28 UAE Declaration on Sustainable Agriculture, Resilient Food Systems and Climate Action, committing its 159 signatory countries to integrate agriculture and food systems into their NDCs by 2025. Further, the COP29 Presidency has proposed a Declaration on Reducing Methane from Organic Waste, towards “1.5°C-aligned” NDC commitments for the waste sector. For the fossil fuel sector, the Oil and Gas Decarbonisation Charter (OGDC) aims for near-zero upstream methane emissions by 2030.

- Significant emissions cuts are possible in the food and agricultural sector, through measures such as reduction of food waste, lower-emitting livestock feeds and breeds, manure management and dietary changes away from farmed meat. Reducing pasture land use aligns with $CO_2$ mitigation options of afforestation or bioenergy with carbon capture and storage (BECCS), both of which require additional land. For rice paddies, emissions can be reduced by removing straw and adopting a non-continuous flooding approach.

- With global warming expected to increase natural methane emissions, further research is needed to improve monitoring of natural methane emissions, especially for regions with limited data. This requires enhanced data collection, expanded observational networks, and improved international collaboration.

# 2 Reductions in air pollution have implications for mitigation and adaptation given complex aerosol–climate interactions.

KEY MESSAGES

- The successful reduction of air pollution has brought significant public health benefits in several regions, but has also reduced the net cooling effect that aerosols exert on the climate. Hence, the reduction of aerosols in the atmosphere has partially "demasked" the full warming impact of accumulated greenhouse gas emissions.
- Changes in aerosol loading in the atmosphere are expected to have regionally differentiated effects on temperature, rainfall, and the incidence of extreme weather events. The nature of these climatic impacts depends on the location of the emission sources, with both local and remote effects.
- Advances in scientific understanding of how aerosols shape global and regional impacts of climate change should inform mitigation targets and adaptation plans.

Aerosols are tiny particles of air pollution from road traffic, fires and other sources, and have a huge influence on global and regional climate. Airborne particulate matter of certain size and origin is also considered the greatest environmental health threat around the world. Recent research shows that the rapid change of aerosol emissions in the lower few kilometres of the atmosphere (i.e., the troposphere) is influencing observed climate change via pathways distinct from GHG (Figure 2).

Broadly, the climate effects of GHG during the industrial era amounts to an increase of the global mean temperature and of total precipitation, while aerosols act as a counterplayer and slightly cool and dry the planet. The details, however, reveal that the effects of aerosols are much more complex than those of GHGs. Aerosols exist in various types and undergo numerous interactions with other atmospheric variables, so are able to either cool or warm the atmosphere. Their atmospheric residence times are considerably shorter than that of $CO_2$, leading to a distinct fingerprint of effects both near the location of emissions and further afield. Aerosols therefore have a much greater impact than $CO_2$ at the regional and local levels, and their cooling effect is more short-term than the warming induced by the well-mixed $CO_2$.

New findings show the extent to which aerosols can modify global warming effects. Depending on the region of aerosol changes and the type of aerosol, they can influence global and regional temperature, precipitation and circulation. Consequently, they can have severe social impacts, including extreme weather events.

In past decades, aerosol loading has decreased in many regions of the world due to successful air pollution mitigation policies, such as over East Asia; in others, e.g., South Asia, they continue to rise (Figure 2). Research on the pattern of recent aerosol emissions changes has revealed much about the remote effects of aerosols on the climate, for example via changing circulation patterns. It is clear that altered aerosol emissions do not only matter for the regions where the sources are located, but can also influence climate risks in remote areas.

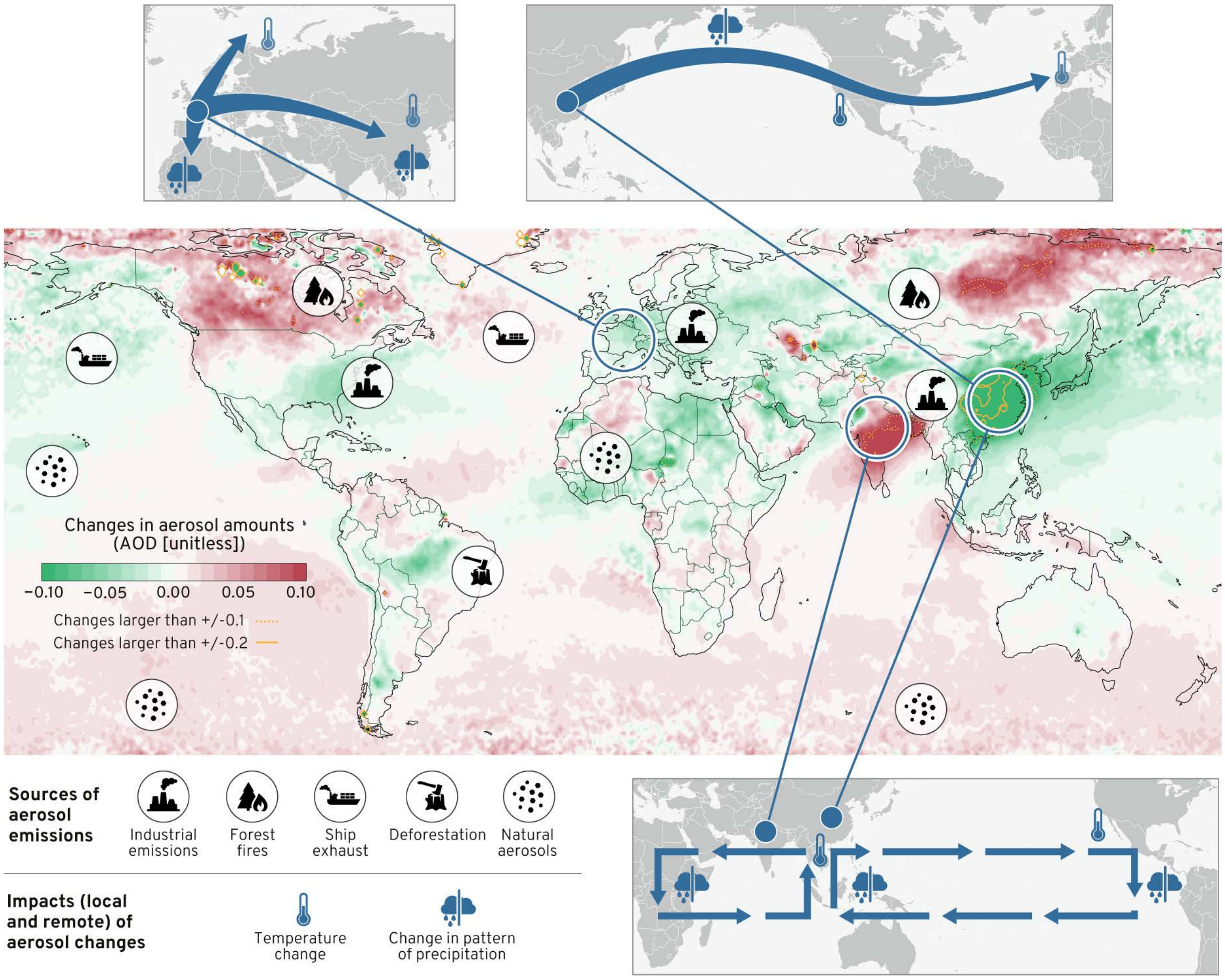


**Figure 2. Recent changes in aerosols, related sources, and examples of remote effects.** Recent changes in aerosol amounts (difference between 2014–2023 and 2004–2013 period averages), quantified as Aerosol Optical Depth (AOD). Main sources of aerosol emissions, responsible for the observed changes. Impacts (local and remote) of changes in aerosol loading over Europe, East Asia, and South Asia are depicted in the top and bottom windows. Modified from Persad et al. (2023).

Beyond these regionally differentiated effects, research based on satellite data helped quantify the impact of aerosol changes on the radiation balance and relate it to the radiative effects of changes in $CO_2$ for the same period. Concurrently, the rate of global warming has increased, and the reduction of aerosol loading is suspected of partially “demasking” the full warming impact of accumulated GHG. The recent findings support what was already known about this (de)masking effect, and have added quantification to narrow uncertainties.

For future climate change, the new results imply that the positive effects of reducing $CO_2$ in net-zero scenarios can be undermined by the demasking from mitigating aerosol emissions. Global warming could temporarily progress even more rapidly, with corresponding societal impacts.

Other new research investigated ship emissions, black carbon, delayed demasking effects for polluted regions, and the possible underestimation of anthropogenic aerosol loading, which to some degree had entered public debates. In short, the studies all support the overall picture that, to fend off global warming, anthropogenic GHG emissions must be drastically and quickly reduced.

Additional research is needed to further improve the quantification of the climate effects of aerosols, especially on the interactions between aerosols, cloud particles and precipitation. Despite the complexity of their roles in the climate system and remaining uncertainties, there is consensus that aerosols decisively influence how fast and in which ways climate change will take shape in different regions. Through their influence on extreme and compound events, there are vital implications for adaptation pressure and for the discussions on loss and damage. Decision-makers should thus take the most recent findings on aerosols into account, using the best available regional climate data and drawing on expert knowledge.

Further reduction of anthropogenic aerosol emissions will reduce health impacts and directly save lives, and is beneficial for climate and the environment. It will, however, amplify climate warming, and can also strengthen precipitation change and extreme events in many regions. It is essential that climate action takes the effects of aerosol changes into account in both adaptation and mitigation strategies.

**POLICY IMPLICATIONS**

- Advances in the scientific understanding of aerosols' influence on climate, specifically on surface temperature, have implications for the level of ambition for GHG emissions reduction goals aligned with the Paris Agreement goals. While the Mitigation Work Programme (MWP) does not explicitly address the effects of changing patterns of aerosol loading, emerging science suggests this is an important consideration for comprehensive mitigation planning, and hence within its mandate. The MWP could play a key role in raising awareness and sharing knowledge about this issue.

- Relatedly, while Nationally Determined Contributions (NDCs) do not account for the effects of changing patterns of aerosol loading, the emerging scientific understanding could justify its inclusion on future updates. The knowledge of aerosols' impact on regional climate change (including patterns of precipitation and extreme weather events) should also inform adaptation planning, reflected in National Adaptation Plans (NAPs).

- Given the complexity of aerosol–climate interactions, a coordinated international science-action effort, similar to what has been achieved for methane, would be important for effectively incorporating aerosols into comprehensive climate action planning. An initial step could be a focused initiative and/or specialised task force to provide recommendations for integrating aerosol considerations into more comprehensive plans. The IPCC-AR7 Methodology Report on Short-lived Climate Forcers expected in 2027 will provide essential guidance on this matter.

- Mitigation of GHG emissions and air pollution can be addressed simultaneously. For example, promoting soil carbon sequestration by adding biomass can reduce agricultural residue burning. Similarly, shifting away from burning fuelwood and charcoal to cleaner cooking methods has been incentivised effectively through subsidised, cleaner cookstoves. The joint benefits for human health and the climate should be communicated clearly, to enhance the adoption of these practices.

- Ongoing research will improve projections and quantifications of the regional climate effects of changing aerosol emissions and loading, which can inform decision-making. Establishing and strengthening air quality monitoring and enhancing procedures for data sharing and transparency can benefit both scientific research and decision-making.

# 3 Increasing heat is making more of the planet uninhabitable

KEY MESSAGES

- Rising heat and humidity due to climate change are pushing more people outside the climatic conditions ideal for human physiology. Currently, around 600 million people live outside habitable climatic conditions, and with each degree of future warming, an estimated 10% of the global population will join them.
- Some regions, concentrated in the Global South, are more exposed to extreme heat and humidity than others. These populations also tend to lack the adaptive infrastructure (e.g., air conditioning) to support continued habitability.
- Heat action plans and early warning systems will become increasingly important as a preparedness strategy for countries and across the most affected regions. Protecting particularly vulnerable groups (outdoor workers, older people, pregnant women, children, among others) will require specific measures.

Humans have flourished within a surprisingly narrow range of climatic conditions, but today increasing temperatures and humidity driven by human-induced climate change threaten to shift the regions that fall within this ideal range. Archaeological records and climate reconstructions, from as far back as 6,000 years ago, reveal that this most habitable range of climatic conditions, the “human climate niche”, has a mean annual temperature of ~13°C and precipitation of ~1,000mm per year. A recent study estimates that due to the ~1°C level of warming already observed, over 600 million now find themselves living in areas outside the human climate niche. At the same time, each degree of future warming would further alter habitability conditions such that the number of people living outside of the “human climate niche” will increase by 10% (Figure 3).

Higher average temperatures, which are also associated with increases in the length and intensity of heatwaves, can lead to heat-related illnesses such as strokes, severe headaches, damage to vital organs, decreased metabolic activity, mental disorders, obstetric complications (see Insight 4), kidney and urinary tract complications, and death. Heatwaves can be especially dangerous when combined with high humidity. Recent studies emphasise that the physical ability to tolerate heat is lower as humidity increases. This implies that a far wider range of regions (and therefore their inhabitants) will be exposed to heat stress than what was previously expected. Besides the direct impacts on human health, increased heat exposure also reduces habitability through disruptions to agriculture. As extreme weather events, including heatwaves, occur more frequently, food insecurity is substantially impacted. El Niño events (see Insight 5) exacerbate heatwaves, and, for example, in southern Africa and Australia, this intense heat greatly affects crop and livestock production, such as occurred during the 2015–2016 and 2023–2024 seasons.

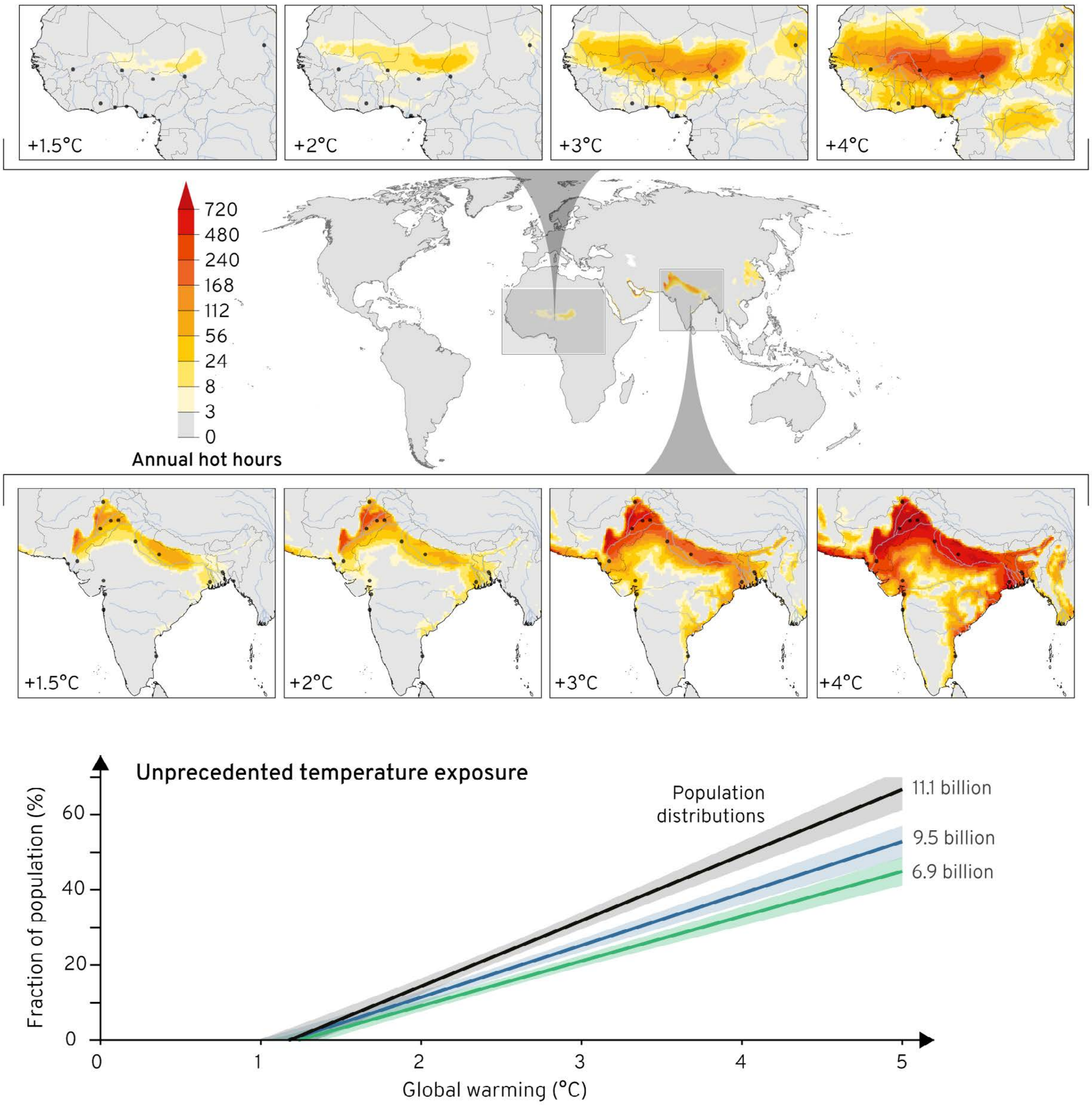


**Figure 3. Increasing exposure to prolonged heat at different levels of global warming.** Map of present heat-humidity risks to humans with inset projections of the heat-humidity changes for West Africa, as well as a plotted projection of the percentage of humanity exposed to unprecedented temperatures, both under different warming scenarios. Annual hot-hours global map (under 1.5°C warming) and West Africa and South Asia projections (under 1.5°, 2°, 3° and 4°C warming): (Vecellio et al. 2023). Bottom plot: Projection of fraction of humanity exposed to unprecedented temperatures (Lenton et al. 2023): Population (%) exposed to unprecedented heat (mean annual temperature ≥29 °C) for the different population distributions: 6.9 billion (green), 9.5 billion (blue) and 11.1 billion (grey).

In the future, many regions will experience an increased frequency, duration and magnitude of heatwaves in addition to higher average temperatures. South Asia and the Persian Gulf are already experiencing deadly heat as the world approaches 1.5°C of warming. Global analyses predict that in general, heat extremes will be concentrated in low-latitude regions, which disproportionately include many Global South countries (Figure 3). The impacts of heat will not just be unevenly distributed globally, but also within the local populations of affected regions. Outdoor workers, older people, young children, people with pre-existing illnesses, and those with cognitive or physical impairments are particularly at risk in extremely hot and humid conditions. Different communities experience heat impacts differently; cities, for example, experience higher temperatures compared to rural surroundings because of the urban heat island effect.

Humans have adopted a wide range of individual, social and structural adaptations that enable them to thrive outside of the ideal climate niche. These adaptation measures will be critical as more regions fall outside the ideal habitability range. With an understanding of the effects of increasing heat and humidity on habitability, proactive adaptation strategies based on future climate projections can be undertaken. Measures such as improved access to air-conditioned and urban green spaces (see Insight 7) can greatly reduce long-term heat exposure, while heat action plans and robust health systems are an essential part of enhancing preparedness to extreme heat events.

Humans can thrive despite increased heat stress, but the necessary adaptations are currently very unevenly distributed. Lower-income countries in the Global South, which are expected to face the brunt of increased heat, are ill-prepared. Poverty within these countries remains a strong predictor of both heat exposure and an inability to sufficiently adapt. Therefore on current trajectories the impact of increased heat and the shifting of the human climate niche will fall disproportionately on already vulnerable communities. This goes beyond deaths, and also encompasses increased pressures on health services, reduced productivity and the general suffering that the projected heat will bring.

**POLICY IMPLICATIONS**

- In the face of rising heat and humidity, developing and implementing comprehensive Heat Action Plans (HAPs) or similar strategies, from country to city level, to prepare for extreme heatwaves is an urgent necessity and could save tens of thousands of lives each year. The key components of HAPs include provisions for healthcare and urban planning, adjustments on labour regulation and education facilities, as well as household behaviour change.

- The Framework for Global Climate Resilience (FGCR) could incorporate specific targets and indicators related to extreme heat preparedness, and emphasise the importance of HAPs and early warning systems (EWS) in its guidance for National Adaptation Plans (NAPs). This aligns with the recommendation from the 2024 UN Call to Action on Extreme Heat.

- Additional specific considerations for heat preparedness:

    - Different segments of the population are particularly vulnerable in specific ways (see Insight 4). Specific provisions are required for older people, children, pregnant women, those with pre-existing conditions, and more generally those in poverty.

    - Humidity has to be factored in, not just absolute heat, when considering both short- and long-term exposure consequences.

    - Aside from extreme heat events, adaptation planning should also consider the effects of long-term heat temperature increase. This requires provisions for new infrastructure, adjustments to building codes, and city scale planning, among others.

    - Other aspects for which preparedness should be considered include: energy infrastructure (added demand), food security (agricultural impacts), water provision, and social cohesion (related to rapid immigration without proper integration strategies).

# 4 Climate extremes are harming maternal and reproductive well-being

KEY MESSAGES

- **The increasing risks of illness and harm for pregnant women, foetuses, and newborns, driven by climate change, are threatening a reversal in the progress made in recent decades in maternal and reproductive health.**

- **Entrenched gender norms and low levels of income and education further amplify the impacts of climate change on maternal and reproductive health. Hence, interventions to minimise the negative impacts should be integrated with cross-cutting approaches to advance gender equity and justice.**

Addressing the effects of climate change on maternal and reproductive health (MRH) is an important element of tackling the gendered impacts of climate change. Changing climate patterns have direct and indirect effects on pregnant women, with more severe impacts in climate-vulnerable regions where there is limited access to resources (Figure 4). Increased pregnancy loss, preterm birth, severe maternal ailments, and cognitive impacts on offspring are some of the risks, yet policy responses are insufficient. Only 27 out of 119 Nationally Determined Contributions (NDCs) make references to maternal and newborn health and sexual reproductive health. There are also gaps in higher education and training on climate change and health, with limited preparedness across healthcare services and social safety nets to address these challenges. While current research shows strong linkages between climate change and MRH, exact pathways are still not clear and research from the most vulnerable regions is under-represented. This makes it difficult to fully understand the magnitude of the impact. Without effectively addressing these gaps, we risk a reversal of the progress made in MRH in recent decades. Urgent calls are being made to increase awareness and catalyse action globally, including the recent “Protecting maternal, newborn and child health from the impacts of climate change” Call to Action by UN agencies ahead of COP28.

Recent studies highlight the growing concern about the effects of climate change on MRH, in particular in climate-vulnerable regions. For example, in India, a study of 800 pregnant working women found that nearly 50% reported exposure to occupational heat stress (working outside of the threshold for safe manual work). The same study found that miscarriage risk was double in pregnant women who were exposed to heat stress compared to those who were not, which has significant implications for tropical nations where millions of women risk exposure to occupational heat stress. In Southern California, researchers found significant associations between long-term heat exposure and increases in birth complications (for example stillbirth and preterm birth), with increased risk in women with lower educational level and less exposure to green spaces. Research across 33 countries in South and Central America, Asia and Africa estimated that flood events may be responsible for over 107,000 pregnancy losses each year in these regions, and reported elevated risk for women with lower income and education levels.

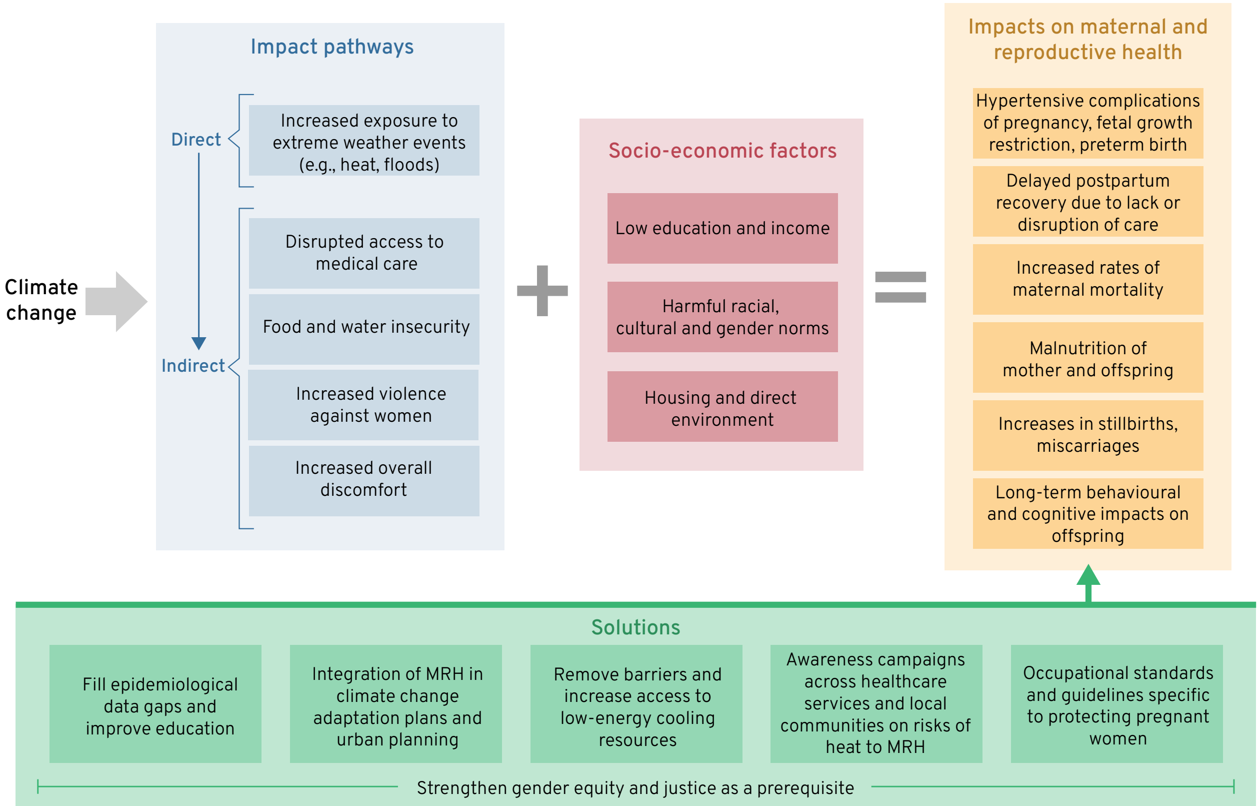


**Figure 4. Direct and indirect pathways of how climate change impacts maternal and reproductive health.** Impacts are further amplified by socio-economic factors in a given setting. To strengthen preparedness and protect maternal and reproductive health in a changing climate, solutions must be driven by gender equity and reproductive justice.

Climate change can also indirectly impact MRH. Increased heat can reduce the availability of food and water, resulting in new mothers needing to travel further in heat, thus experiencing delayed recovery from birth. Food insecurity is linked with inadequate nutrition during pregnancy, lower birth weight and reduced breast milk production. Studies have also reported declines in breastfeeding frequency, reduced travel for medical care and lower use of mosquito nets in extreme heat, all of which have MRH implications. Research in three South Asian countries found that a 1°C increase in annual mean temperature was associated with a 4.5% increase in intimate partner violence. Climate-related displacement has been linked to inadequate healthcare support, lack of proper nutrition; inadequate rest, sanitation and social support networks; as well as an increased risk of sexual violence. While this chapter focuses on extreme heat and flooding, it is important to mention that other climate change driven impacts such as air pollution continue to be a major concern to MRH.

Solutions addressing the effects of climate change on MRH cannot be separate from justice and gender-transformative rights-based approaches. Women of colour, and with low income and education levels, face greater impacts of climate change and have limited access to healthcare services, meaning they face disproportionate challenges to their MRH. Entrenched gender norms restrict pregnant women from changing harmful practices (e.g., collecting firewood and water) even in extreme heat. Increasing women's rights to participate in decision-making processes will help the formation of policies, programmes and standards to protect MRH from the impacts of climate change.

**POLICY IMPLICATIONS**

- While health is a high-priority component of National Adaptation Plans (NAPs) and Nationally Determined Contributions (NDCs), explicit attention to sexual, maternal, reproductive, and children's health is very limited. The NAP Global Network and the UN Population Fund have raised concern about this blind spot.
    - Awareness of the increasing risks that climate change carries specifically to pregnant women, foetuses, and newborns should motivate new NAPs to include specific provisions for this.
    - The Framework for Global Climate Resilience (FGCR) could recognise maternal and reproductive health (MRH) as a key area of concern in climate adaptation, and place greater emphasis on addressing the social determinants of MRH that intersect with climate change impacts, such as poverty, gender inequality, and limited access to healthcare.
- Adding to the specific considerations for heat preparedness in the NAPs suggested for Insight 3, others focused on MRH include:
    - Awareness and education programmes for community groups, such as maternal health workers, women support groups, traditional birth attendants, and local leaders, on the specific risks of heat to MRH, including detection of early signs of dehydration.
    - Institutionalise labour guidelines to protect pregnant women during extreme weather conditions, with measures in place to ensure these do not result in additional challenges for women to get or retain their jobs when pregnant.

# 5 Concerns about El Niño–Southern Oscillation and the Atlantic Meridional Overturning Circulation with an increasingly warm ocean

**KEY MESSAGES**

- Unprecedented ocean warming since 2023 has broken sea surface temperature (SST) records, increasing scientific concerns about the potential consequences in large-scale processes in ocean and ocean–atmosphere interactions. New research on the physical impacts of global warming on 1) El Niño-Southern Oscillation (ENSO), potentially leading to more extreme El Niño events; and 2) the Atlantic Meridional Overturning Circulation (AMOC), potentially threatening its stability.

- The economic impacts of El Niño are far more severe than previously understood, with global income losses from past events adding up to trillions of US dollars. Moreover, the projected additional economic losses due to increased El Niño frequency and intensity resulting from global warming could be as high as US$84 trillion over the 21st century.

- AMOC could be closer to a critical slowdown, or even collapse, much earlier than previously estimated. The consequences for global climate, weather patterns, and human well-being would be severe.

- Future warming might be underestimated by current climate models due to biases and short observational records. Closing these gaps is crucial for improving predictions, conducting more robust risk assessments, and developing more effective adaptation strategies.

New research reveals two critical ocean-related risks. First, the global economic costs of El Niño impacts are much higher than previously thought, highlighting the vulnerability of our economic and social systems to ocean changes. Second, the AMOC, a key global ocean current system, may slow down or collapse sooner than earlier models projected. We feature these two ocean and ocean-atmosphere processes, as they illustrate that human well-being is highly sensitive to ocean variations and that significant oceanic changes are likely in the near term, posing substantial societal risks.

Since early 2023, global SST has reached unprecedented highs, breaking records not only in the tropical Pacific due to El Niño, but also in the North Atlantic, Gulf of Mexico, Caribbean, and Southern Ocean. Even after the 2023–2024 El Niño event faded, temperatures remained nearly 0.5°C above the 1991–2020 average through June 2024 as of this writing. These changes in SST and the associated El Niño event have significant social and economic impacts.

Despite the physics of the El Niño-Southern Oscillation being well-understood, societies remain

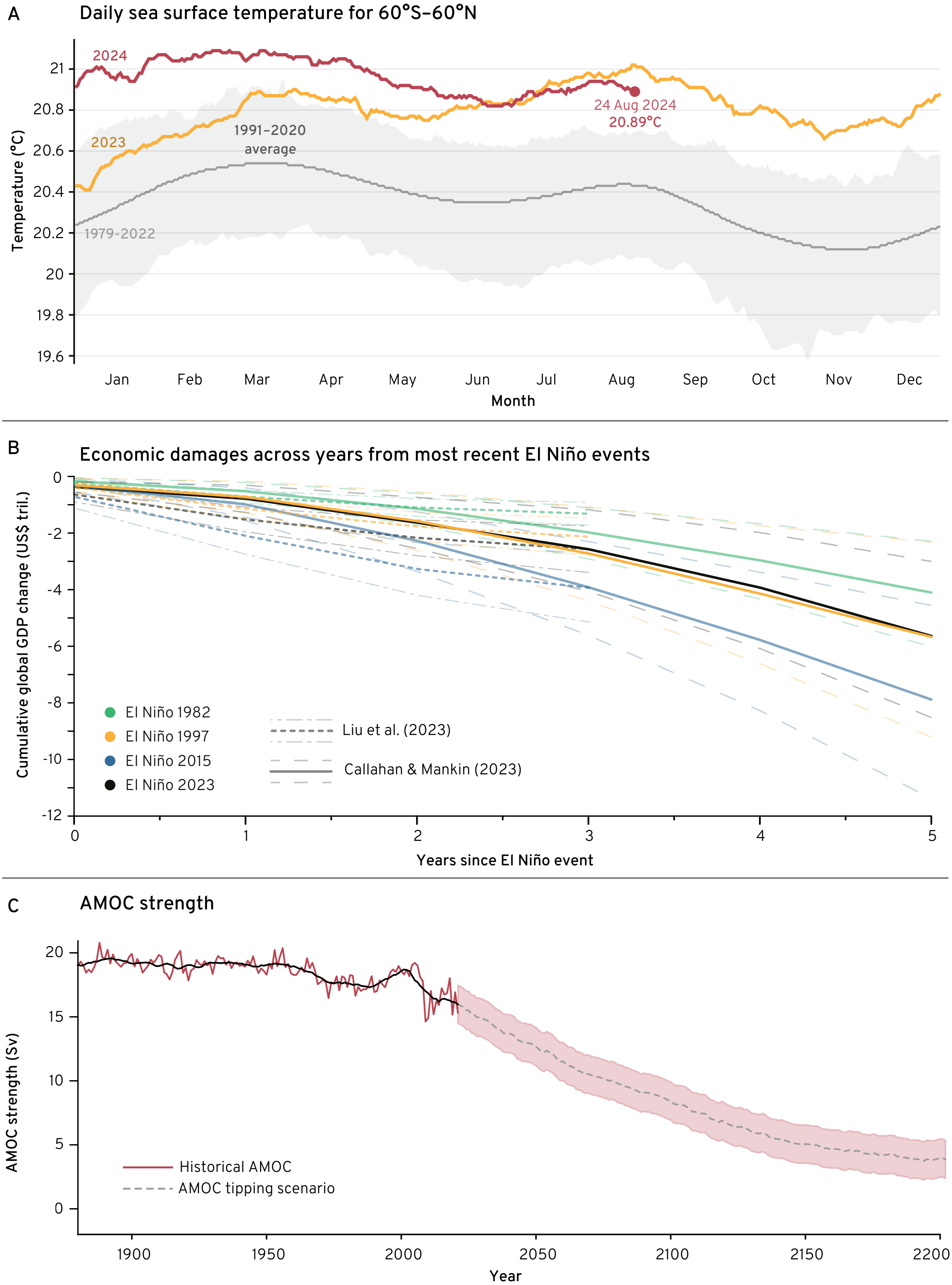


**Figure 5. Unprecedented sea surface temperature, El Niño costs, and potential weakening of AMOC. (A)**The mean daily sea surface temperature (SST) across the globe, collected from January 1979 to August 24, 2024 (EU Copernicus Climate Change Service). **(B)** Economic damages calculated as GDP change after El Niño events. The centre line indicates the mean of the projection and shading shows the 95% confidence intervals (Liu et al. 2023; Callahan and Mankin 2023). **(C)** The historical AMOC strength based on a combination of annually-averaged SST observations and reconstructions indicating potential AMOC tipping scenario from 2021–2200 (grey dashed) with shading of interannual variability and uncertainty.

highly vulnerable to these events, with economic losses persisting for at least six years after an El Niño event. New research shows that the impacts of natural climate variations like El Niño are more than two orders of magnitude costlier to the global economy than previously thought, with past events causing trillions of dollars in losses. For example, the 1982–1983 and 1997–1998 El Niño events alone led to global income losses of US$4.1 and $5.7 trillion, respectively (Figure 5). Equally startling losses of US$2.1 trillion for the 1997–1998 and US$3.9 trillion for the 2015–2016 events are estimated by another study (Figure 3). For comparison, the gross domestic product (GDP) for Germany, the third largest economy in the world, was about US$4 trillion in 2022. The astounding costs of El Niño suggest that society is poorly adapted to present-day ocean temperature variability even without additional changes from global warming. Both studies suggest that macroeconomic losses grow dramatically with projected warming and El Niño changes. By one estimate, future El Niño events could cost the global economy US$84 trillion, the equivalent of the top 20 global economies combined, by the end of the 21st century.

Recent research shows that the AMOC is weakening due to planetary warming-driven changes and may decline further within this century. While the Intergovernmental Panel on Climate Change (IPCC) previously assessed that an AMOC collapse was unlikely this century, this evidence suggests it could happen sooner than expected. Although the limited 20 years of modern observations provide no detectable trends, they do, alongside past climate reconstructions and model simulations, indicate the type of system behaviour and early warning signs suggestive of slowing circulation and potential collapse. If the AMOC weakens or collapses, it would have significant and complex impacts on global climate, sea levels, marine ecosystems and, subsequently, human societies. This calls for urgent monitoring and mitigation efforts.

To understand the climate risks we face this century, it is crucial to assess the reliability of climate models and the quality of observations. Most recent models suggest that El Niño events may become more intense even with strong mitigation efforts (though there are uncertainties due to biases in these models, particularly in predicting SST). Therefore, the actual warming could be even greater than previously predicted for the same emission scenario. Research should focus on bridging the gap between model results and observations such as SST, especially those used for predicting changes in El Niño and the AMOC. Improved models and longer, more accurate observational records are essential for reducing uncertainty and better preparing for future climate risks. To protect society from climate risks, science needs to address uncertainties in predictions.
It is crucial that we have improved models, and properly understand the impact of rising SST. Policymakers should recognise that some risks remain beyond exact scientific prediction but have severe socio-economic and physical impacts, making it a critical consideration to inform risk assessments underpinning mitigation and adaptation plans.

## POLICY IMPLICATIONS

- Although El Niño events are part of the natural climate variability and occur at predictable intervals, the magnitude and persistence of the economic losses they cause is indicative of how poorly adapted most economies are to such impacts. El Niño impacts, such as amplified droughts, floods, and heat extremes, mirror the broader consequences of global warming. Strengthening adaptive capacity and resilience to El Niño events can also enhance overall preparedness for climate change.

- Scientific evidence suggesting more intense ENSO events due to global warming, and their potential economic impacts, should alert governments on the importance of incorporating this knowledge into the Framework for Global Climate Resilience (FGCR). In particular, this should be reflected in defining concrete targets, progress indicators, and means of implementation, expected by 2025. It is especially important for tropical countries economically dependent on their agricultural sector to prioritise the inclusion of ENSO-related impacts on their National Adaptation Plans (NAPs).

- The projected macroeconomic toll of rising ENSO impacts under current trends of global warming should add a sense of urgency to close the adaptation finance gap, given the risk of higher economic losses further limiting the capacity for adaptation investments.

- The severe costs of El Niño highlight the potential for even greater social and economic disruption if the AMOC slows or collapses, which would push the climate into an unprecedented state. However, the likelihood and timing of such an event are uncertain.

- The UNFCCC could request the IPCC to produce a report on “high-impact, low-likelihood” phenomena, including climate tipping points, to provide clear scientific guidance for policymakers.

- Investments are needed to strengthen long-term ocean monitoring capabilities, including key indicators relevant to ENSO and AMOC; improve climate models with coupled ocean–atmosphere dynamics to reduce uncertainties; enhance regional climate projections; and promote interdisciplinary integration, including socio-economic analyses.

# 6 Biocultural diversity can bolster the Amazon's resilience against climate change

**KEY MESSAGES**

- The Amazon is under increasing pressure from multiple threats, leading to ecosystem degradation. Some areas are already shifting from carbon sinks to carbon sources, and there is growing concern about further disruption of water recycling at a regional scale. Both of these processes can have far-reaching consequences for regional and global climate.

- Due to climate change, Amazon forests are approaching multiple thresholds (related to temperature, rainfall, and seasonality), beyond which significant ecological changes can be triggered, potentially leading to a large-scale forest collapse. Deforestation and forest degradation through local activities (e.g., logging, agricultural expansion) lead to habitat fragmentation, further eroding resilience to climate change.

- Extensive mitigation is critically needed for reducing the impacts of climate change that erode the forests' resilience, such as extreme droughts and fires. But local and regional actions that preserve and increase the forests' ecological and cultural diversity can play a crucial role to strengthen its resilience to climate change.

The Amazon is a heterogeneous and complex system, shaped over tens of millions of years and composed of various types of interconnected aquatic and terrestrial ecosystems. It hosts ~10% of the Earth's terrestrial biodiversity and more than 400 ethnicities of Indigenous peoples and local communities. By regulating temperature and precipitation and sequestering carbon, it dampens human-induced climate change, and by recycling around 16–22% of Earth's freshwater, it substantially affects the planetary energy balance.

But human impacts are reshaping the Amazon. Legal and illegal logging; agricultural expansions; intentional burning; the development of disrupting infrastructure such as dams and roads; the non-sustainable extraction of goods; an increasing urban population; and climate change-induced rising temperatures and changing rainfall patterns are all increasingly eroding the resilience of biophysical and social systems.

Critical warning signs are emerging; some parts of the forest have switched from carbon sink to carbon source, effectively reinforcing climate change. Events such as the 2020–2022 flooding and the subsequent 2023–2024 drought have substantially harmed socio-ecological systems throughout the Amazon basin. Impacts were observed on people (e.g., displacement, transportation shortages) and ecosystems (e.g., reduced productivity). The repercussions extend far beyond the region, threatening water, energy, and food security locally and globally, and jeopardising the stability of the forest itself. Growing concern centres on the possibility of a

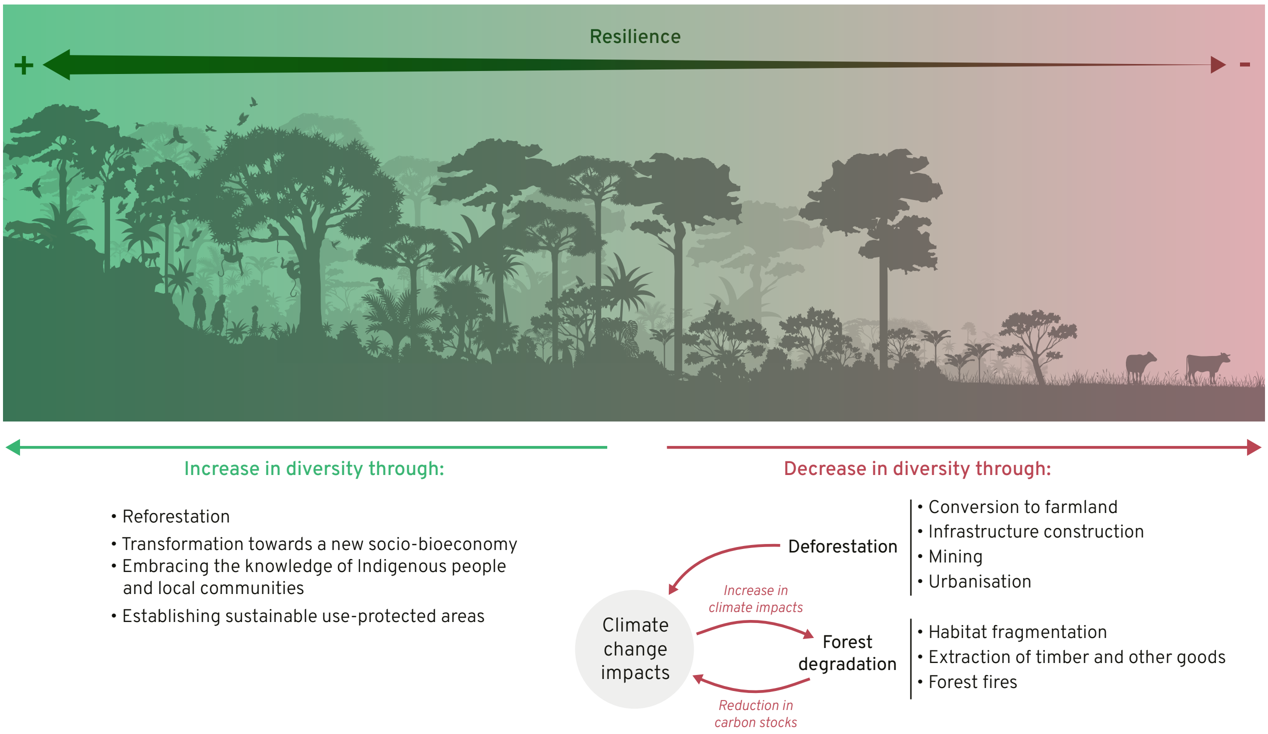


**Figure 6. Amazon's biological and cultural diversity enhance its resilience to climate change.** Deforestation and forest degradation in the Amazon reduce biodiversity and amplify climate change by depleting carbon stocks, creating a self-reinforcing feedback loop. Enhancing the Amazon's biological and cultural diversity strengthens its resilience towards climate change, helping to break this cycle.

systematic collapse triggered by self-reinforcing feedback loops and the crossing of critical climate thresholds. While local or regional tipping points are expected to occur first, the large-scale tipping of the Amazon rainforest may soon follow.

Increasing the resilience of the Amazon basin is crucial to reduce the risk for future ecological and societal disasters. The diversity of the Amazon basin is strongly linked to the resilience of the ecosystem (Figure 6), especially in the face of disturbances mentioned above. These threats, unevenly distributed across space and time, are pushing the system toward various thresholds – on temperature, rainfall, seasonality, dry season length, and deforestation – at different rates. Temperature thresholds can significantly impact photosynthesis efficiency, bringing the forest closer to its physiological limits. A richer diversity of biological functions or ecological roles within the ecosystem (i.e., functional diversity) enhances the Amazon's resilience to climate change, underscoring the importance of plans to conserve and restore biodiversity to strengthen forest resilience.

To halt the environmental and economic practices driving the destruction of the Amazon, concerted local and regional changes are crucial. Restoration at regional scale can restore significant amounts of carbon stocks, disrupting the self-reinforcing feedback loop between climate change and forest degradation. Co-developing reforestation plans locally should also aim to strengthen rural economies and improve livelihoods in the long term, empowering local communities and Indigenous people. Developing an economy that values the environment is essential. Biocultural diversity, especially regarding land management practices, is important to ensure the continued provision of ecosystem services, as well as to generate opportunities to improve the living conditions of rural, forest, and urban populations who currently face poverty and inequality. The foundation for this sustainable use is broad and diverse, encompassing traditional activities of forest communities, biodiversity-rich family farming, and all stakeholders within rural landscapes.

Protecting the Amazon rainforest is critical for stabilising the climate. But climate change is already shaping the forest with conditions that exacerbate fire and droughts. Local and regional actions to increase the Amazon's resilience by protecting cultural and ecological diversity are crucial, but ultimately the future of the Amazon depends on globally concerted efforts to reduce greenhouse gas emissions.

**IN FOCUS: SOCIAL-ECOLOGICAL "HOPE SPOTS"**

Social-ecological "hope spots" are emerging across Amazonian Indigenous and local communities, despite the challenges. These are areas where Indigenous and local communities collaborate with science and technology initiatives to produce new models of biodiversity and cultural heritage conservation, demonstrating successful cases of biocultural conservation. Community-based conservation initiatives for sustainable-use protected areas – where local communities are empowered to protect their own territories against illegal fishers, loggers and poachers and have a large degree of autonomous decision-making – have proven effective to both maintaining biocultural diversity and conservation while also enhancing livelihoods in rural Amazonia. By acting as buffers against large-scale deforestation and degradation, Indigenous territories and protected areas play a critical role in preserving the Amazon's resilience and biodiversity.

**POLICY IMPLICATIONS**

- At COP28, Brazil stressed the importance of the Amazon, and re-stated the commitment to ending deforestation by 2030, originally put forward at the Glasgow Leaders' Declaration on Forests and Land Use (COP26), with over 100 countries joining the Global Forest Finance Pledge (US$12 billion, in five years). Significantly, Brazil has proposed the development of a Tropical Forest Forever Fund (TFFF), aiming to mobilise US$250 billion annually for tropical forest conservation. With its focus on climate finance, COP29 in Baku should see progress towards the TFFF, for which Brazil aims to have a fully operational facility by COP30 in Belém.

- Countries with Amazonian territories must strengthen law enforcement capabilities and penalties, to control the main drivers of deforestation – in particular, combating illegal logging and mining, which threaten Indigenous and local communities, as well as further agricultural expansion. For local communities reliant on unsustainable activities, governments should promote and support the voluntary adoption of alternative livelihoods strategies.

- Ensuring the continuity and funding of programmes for the monitoring of forest cover and use, including earth observation and commodity traceability tools, is essential for policy development, law enforcement and advancing basic research.

- Supporting Indigenous and locally led initiatives for sustainable economic development in synergy with protection and restoration of biodiversity should be prioritised. There is political momentum stemming from the Belém Declaration, signed at the Amazon Summit (2023) by the eight countries that share the Amazon, in which they commit to regional cooperation to halt deforestation and promote sustainable forest management, emphasising Indigenous knowledge and guaranteeing their territorial rights.

# 7 Critical infrastructure is increasingly exposed to climate hazards, with risk of cascading disruption across interconnected networks

KEY MESSAGES

- Critical infrastructure is threatened by more frequent and intense climate hazards. Potential cascade effects through interconnected systems are a significant risk.
- Artificial intelligence (AI) has the potential to make infrastructure and nature-based solutions more robust, efficient and better adapted to climate impacts.

Critical infrastructure includes assets, networks and systems that are needed for the provision of essential services. When it is damaged, even briefly, the provision of electricity, natural gas, food and drinking water, as well as waste collection and treatment, telecommunication networks and healthcare services, can be disrupted. Escalating challenges posed by climate change – in particular, extreme weather events that are becoming more frequent and severe – are testing the resilience of critical infrastructure. Vital social and economic functions are on the line.

Climate hazards can involve single, compound or coincident extreme weather events, and their impacts can cascade through interconnected systems. Interdependencies between critical systems such as electricity distribution and healthcare, or food supply and transport, can intensify vulnerabilities, causing a domino effect where one failure spreads and disrupts other systems. Assessing vulnerabilities to climate change requires consideration of location-specific conditions, socio-economic trends and legacy factors, as each will affect how systems respond to climate impacts. Tailored strategies are needed for robust resilience and adaptation mechanisms.

There are a range of proposed solutions to the energy sector's vulnerability to climate-related hazards. Sometimes, highly targeted interventions can substantially increase the resilience of a network. For example, the identification and protection of critical power lines representing just 1% of the network in Texas's power grid significantly reduced hurricane-induced power outages by a factor of 5 to 20. On the other hand, smart grids powered by artificial intelligence (AI), machine learning (ML) and predictive analysis can raise overall resilience across energy infrastructure. AI/ML tools can assist monitoring grid operations and responding to disruptions in a timely manner. They can also support predictive maintenance and cybersecurity algorithms and forecast the production of renewable energy levels, while also ensuring reliable energy supply in a dynamic environment. Similar tools could enhance resilience in other critical infrastructure systems such as water management, transportation and telecommunications.

Climate adaptation in urban areas is closely linked to enhancing the resilience of critical infrastructure. For example, denser urbanisation can increase the urban heat island effect, leading to greater demands for cooling and higher strain on energy grids, increasing the challenge of energy transition. When populations grow, so does economic activity and resource concentration in urban areas, which require resilient infrastructure. Addressing bottlenecks and threats in supply chains for electricity, food, fresh water and more is essential, as populations in urban areas are expected to double by 2050 compared to 2023, with more than one billion people predicted to live in informal settlements, particularly in the global South, that are especially vulnerable and high risk. Detailed assessments of climate risks and vulnerabilities are thus needed to help prepare for extreme climate events, in particular for underserved and marginalised communities. Nature-based solutions that could potentially mitigate the anticipated climate impacts are also an area of increasing focus, including urban green infrastructure such as vegetation and soil cover for reducing local temperatures and mitigating flood risk, providing social and ecological benefits.

**POLICY IMPLICATIONS**

- Initiatives like the Global Methodology for Infrastructure Resilience Reviews launched at COP28 by the United Nations Office for Disaster Risk Reduction (UNDRR) and the Coalition for Disaster Resilient Infrastructure (CDRI) evidence the growing urgency and importance of climate risk assessment for critical infrastructure at the national level. This is the first global methodology providing a holistic approach to infrastructure systems resilience. It supports countries in assessing their current state and identifying areas for improvement.

- Relatedly, this Insight underscores the importance of the Early Warnings for All Initiative, co-led by the UN Office for UNDRR and WMO, aiming for full global coverage by 2027.

- Additional specific considerations for the resilience of critical infrastructure in the energy sector:

    - The trend of increasing electrification will create strong interdependencies with other critical infrastructure systems. Hence, investing in the resilience of electricity networks to better withstand climate-related issues will safeguard other interconnected infrastructures.

    - Increase dispersed energy networks, such as microgrids, while considering combining with renewables and compatibility with other sectors, to increase equity, resilience, and access to clean energy, support sustainable development and reduce high interconnectedness vulnerabilities.

    - Improve guidelines for planning, designing and governance for local sustainable infrastructure construction, including integrated microgrids and linked social/physical infrastructures to enable efficient energy distribution and increased equity, and to manage risks in vulnerable communities during emergencies.

# 8 New frameworks for climate-resilient development in cities provide decision-makers with ideas for unlocking co-benefits

**KEY MESSAGES**

- Few cities include effective mitigation and adaptation strategies in their action plans, even though climate-related risks are predicted to impact billions living in cities.
- Climate-resilient development can be operationalised more effectively with a social-ecological-technological systems (SETS) approach. Smart solutions and technologies can facilitate the adoption of the SETS approach, ensuring co-benefits and minimising trade-offs.
- Cities in various stages of development – emerging, rapidly growing, established, and shrinking – face distinct challenges posed by climate change, requiring tailored development strategies for each context.

As climate change intensifies, billions of people in cities around the world will be at risk of climate-related hazards. Many are already dealing with the impacts of the climate emergency. Around 80 of the 100 fastest growing cities in the world, which are also classified at high risk of climate change, are in Asia and Africa and include commercially important capitals such as Jakarta, Lagos and Addis Ababa. Systemic challenges, such as out-migration leading to shrinking cities, and the ageing of populations, can reduce residents' ability to withstand and adapt to, and rebuild after extreme events.

While both mitigation and adaptation efforts are imperative to integrate into cities' planning and actions, local governments often have to prioritise one over the other according to available budgets and funding. Imbalanced considerations and actions can lead to suboptimal outcomes and trade-offs between mitigation and adaptation. With climate action at its core, and a focus on ensuring vulnerable populations are not left behind, climate-resilient development fitted with a social-ecological-technological systems (SETS) approach supports sustainable development in an integrated manner. This approach can help cities to implement local-level climate action within a broader sustainable development agenda.

Systems approaches that consider cities as dynamic and open can help decision-makers to identify and minimise trade-offs that can be missed or exacerbated when isolated or bilateral measures are taken. The SETS approach examines interactions and interdependencies, broadening the spectrum of intervention options and the potential for co-benefits, for example in adaptation, mitigation, biodiversity, health, equity and more. As an example, cities have recorded high heat-related deaths and illnesses in recent years. Socio-economically disadvantaged neighbourhoods with less greenery are hit hardest, and own fewer cooling facilities. Additionally, both rural and cross-boundary migration in some cities has drawn poor households to informal settlements in hazard-prone areas, of which recurrent climate impacts, such as floods, lead to a poverty trap, increasing vulnerability and inequality

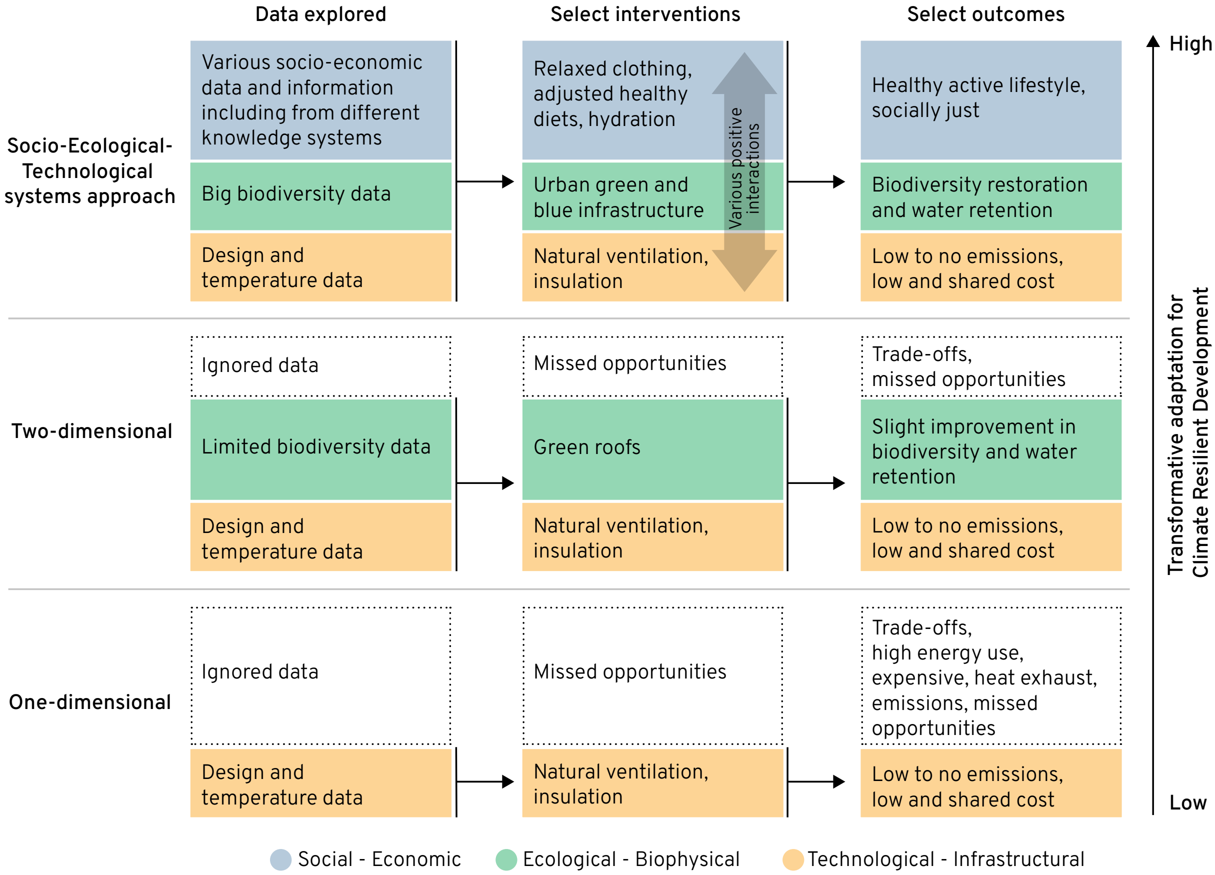


**Figure 8. Social-ecological-technological systems (SETS) approach to urban heat.** Illustrated solutions to urban heat using a SETS approach (McPhearson et al. 2022) compared to conventional (one-dimensional or two-dimensional) approaches, to guide planning and integrate policies with co-benefits from positive interactions among interventions (as indicated in the top right corner).

in society. Yet, when new green space programmes do not consider this social-ecological-technological interplay on heat vulnerability, they may allocate the cooling benefits disproportionately in wealthier neighbourhoods or lead to gentrification, further intensifying inequality in adaptation. Air conditioning, while important for adapting to extreme heat and saving lives, is energy-intensive, emits heat and GHGs, creating feedback loops through heat exhaust and is often unaffordable. The SETS framework applied to this case illustrates the advantages of integrating various dimensions to generate holistic solutions (Figure 8). Ecological strategies like green and blue infrastructure, and social measures such as behavioural interventions, can help reduce the need for air conditioning while mitigating heat-health risk. This integration minimises trade-offs and maximises co-benefits, fostering more resilient and liveable cities.

Fast-growing cities in low- and middle-income countries need support to develop critical green and blue infrastructure. These cities often lack socio-economic capabilities or adaptive governance mechanisms, especially those with informal structures. Smaller cities can also lack climate-related funding streams and rely quite heavily on central government budgets, which delays planning processes.

Overall, innovative mechanisms that encompass all components of SETS are better suited to deal with trade-offs and conflicts. In doing so, cities can move towards climate-resilient development based on transformative decisions.

## POLICY IMPLICATIONS

- Momentum for a more central role of cities in global climate action has been growing since COP26. At COP28, the Coalition for High Ambition Multilevel Partnerships (CHAMP) and the Joint Outcome Statement on Urbanization and Climate Change focused on empowering cities and local governments to strengthen climate action through multilevel collaboration. In particular, these efforts push for the incorporation of stronger urban content into Nationally Determined Contributions (NDCs).

- An integrated social-ecological-technological systems (SETS) approach can serve as a guide for operationalising urban climate-resilient development, enhancing co-benefit and prioritising synergistic solutions that enable local adaptation to climate change impacts while contributing to global efforts to reduce GHG emissions. This resonates strongly with the COP29 Presidency initiative on Multisectoral Actions Pathways (MAP) Declaration for Resilient and Healthy Cities. Intervention highlighted in the literature include:

    - Green infrastructure and solar passive building designs coupled with new behavioural norms on dress codes, for example, reduce heat stress, as well as GHG emissions from building operations.

    - Urban planning and governance supported by big data analytics and AI tools to maximise co-benefits and minimise trade-offs. AI-supported decision-making enables far more powerful assessment of multiple interactions across various social-ecological-technological components of the urban system.

    - Invest in improved capacities for adaptive governance and transformative urban planning.

    - Build innovative institutional partnerships that include local communities and the private sector to improve implementation and management of urban infrastructure and services.

- Interventions for managing climate risks must be designed to respond to the specific ecological and vulnerability contexts of the city. Strategies and solutions must be tailored to the unique challenges faced by cities at different stages of their development, whether emerging, rapidly growing, established, and/or shrinking.

- Policy interventions must recognise and address socio-economic inequities and entrenched vulnerabilities because of past urban planning legacies, present informal settlements at high-risk areas, and new policies leading to green climate gentrification. This will prevent reinforcements of injustices and maladaptation.

- Multi-level and multi-actor capacity development strategies and programmes that address the need for adaptive local governance in the context of growing uncertainties and rapid urbanisation are needed, particularly in low- and middle-income countries.

- Build innovative institutional and partnership strategies that include local communities and the private sector to improve implementation and management of urban infrastructure and services.

# 9 Closing governance gaps in the energy transition minerals global value chain is crucial for a just and equitable energy transition

KEY MESSAGES

- As demand for renewable energy technologies rises there are growing concerns about trade dynamics and value chain-related challenges for energy transition minerals (ETMs).
- The ETM value chain has significant environmental, social and economic impacts, which are felt hardest in the Global South.
- Addressing the governance gaps within the ETM value chain is a major challenge for a just energy transition that avoids greater burdens and fewer benefits for Global South countries.

The demand for ETMs – minerals and metals essential for clean energy technologies such as cobalt, copper, lithium and rare earth elements – has risen sharply due to the global push for low-carbon development and energy security. While specific mineral criticality varies by country based on domestic reserves, supply chain risks, supply predictability, prices and national security needs, ETMs are essential worldwide for renewable energy systems, including batteries, solar panels and wind turbines.

Forecasts show a major gap between future mineral needs and current known reserves. By 2050, annual lithium demand could exceed 25% of known reserves and be 12 times current production levels. Cobalt demand might range from 6,000 to 3.6 million tonnes per year against global reserves of 8.3 million tonnes. Similarly, rare earth element consumption is expected to quintuple by 2030 compared to 2005, potentially surpassing global known reserves by 2050. The extraction, processing and disposal of these minerals can also generate enormous amounts of waste – by 2050, the extraction of copper, nickel, manganese, and lithium alone could produce 953 gigatonnes of dry waste over the 2020–2050 period. As mineral demand surges, understanding the ETM value chain – spanning extraction, processing, and distribution – is essential to managing the global distribution of benefits and environmental and social burdens (Figure 9).

As the demand for ETMs increases, new geopolitical dynamics emerge, with governments taking strategic actions such as imposing mineral import bans, forming alliances to secure supply chains, increasing domestic mining operations, and strengthening domestic processing. Expanding mining operations into ecologically vulnerable areas may create further risks, while a mineral-intensive energy transition could still lead to supply shortages. Balancing national priorities with international collaboration is essential to prevent delays in the global energy transition.

A responsible ETM value chain must go beyond economic and technological factors, needing to prioritise environmental protection, social justice, benefit sharing and fair trade principles (Figure 9). The concept of a "just energy transition" incorporates labour rights, governance, and socio-political

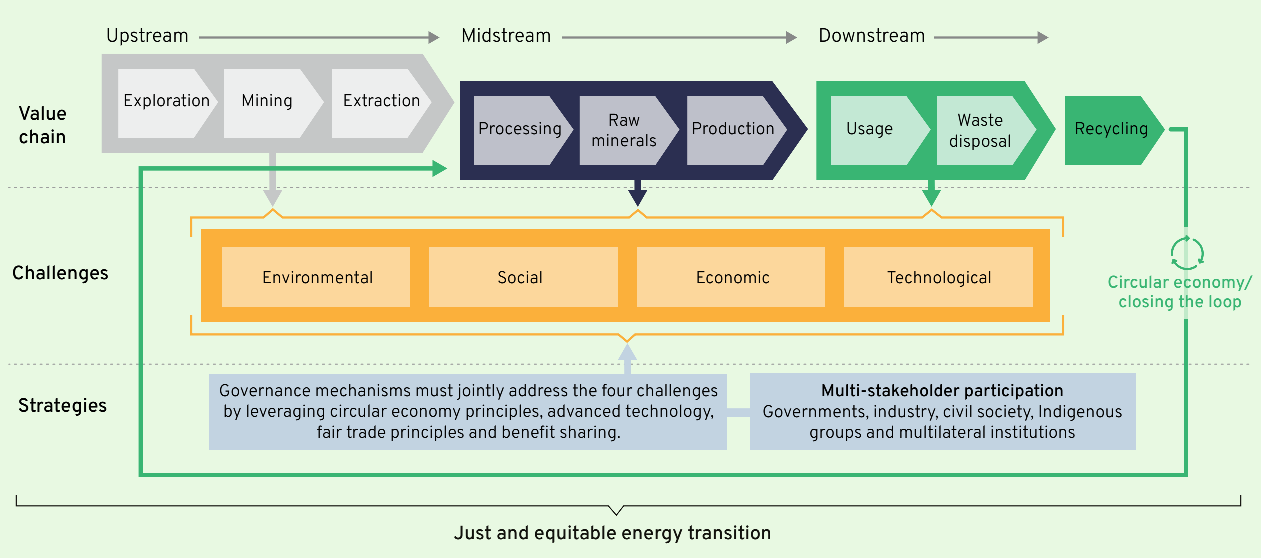


**Figure 9. Addressing challenges of ETM value chain to achieve a just and equitable energy transition.** The ETM value chain and the challenges different stages present across environmental, social, economic and technological domains.

dimensions, ensuring that the transition to clean energy does not exacerbate inequalities or harm vulnerable communities. Emerging frameworks like planetary just transitions, which integrate decolonial perspectives, offer a broader approach to addressing the complex challenges of ETM value chains.

Resource-rich countries in the Global South often bear the brunt of these impacts while benefiting less from the energy transition. A critical challenge in governing ETM value chains lies in the Global North's dominance over high-value-added production and consumption, despite the Global South's resource wealth. Disparities in trade policies, technological capacity, and economic diversification hinder the Global South's ability to fully benefit from the energy transition. Stockpiling by Global North countries exacerbates supply constraints and price inflation, exacerbating inequities. For example, while cobalt mining is concentrated in the DRC, DRC-owned companies control less than 5% of production. The search for new mineral sources could also harm local communities and engender opposition. A recent study found that 69% of over 5,000 global ETM projects are located on or near land classified as Indigenous people's or peasant land. Their overlap with protected areas, biodiverse regions, and Indigenous lands contributes to biodiversity loss, land degradation, water scarcity, and pollution.

Ensuring a responsible ETM value chain requires concerted efforts to minimise environmental impacts, uphold labour standards and fair terms of trade, and foster multi-stakeholder participation throughout the value chain. Current voluntary standards and regulations, such as the International Council on Mining and Metals (ICMM), Extractive Industries Transparency Initiative (EITI), and EU directives on corporate sustainability, aim to improve transparency and due diligence throughout the value chain. However, these mechanisms are often uncoordinated and insufficient, while comprehensive governance mechanisms that balance geopolitical interests, harmonise trade, planetary justice and climate policies, and involve civil society remain limited. The United Nations has called for improved, coordinated action through a working group on Transforming Extractive Industries for Sustainable Development and a Panel on Critical Energy Transition Minerals to establish common principles.

Governance mechanisms across the ETM value chain must be people-centred and planetary justice-centred, proactively addressing environmental, social, economic, and technological risks throughout the entire value chain. International cooperation and circular economy principles must counter the trend of national interest policies at the expense of a just and equitable global energy transition. Ethical sourcing, transparency, and traceability from extraction to end use are critical to ensuring that the benefits of the energy transition are shared equitably across the globe.

**IN FOCUS: GUIDING PRINCIPLES ON CRITICAL ENERGY TRANSITION MINERALS**

The UN Secretary-General's Panel on Critical Energy Transition Minerals has put forward seven voluntary guiding principles, drawing upon established norms, commitments, and legal obligations outlined in UN documents:

- Principle 1 – Human rights must be at the core of all mineral value chains.
- Principle 2 – The integrity of the planet, its environment and biodiversity must be safeguarded.
- Principle 3 – Justice and equity must underpin mineral value chains.
- Principle 4 – Development must be fostered through benefit sharing, value addition and economic diversification.
- Principle 5 – Investments, finance and trade must be responsible and fair.
- Principle 6 – Transparency, accountability and anti-corruption measures are necessary to ensure good governance.
- Principle 7 – Multilateral and international cooperation must underpin global action and promote peace and security.

**POLICY IMPLICATIONS**

- The announcement at COP28 of the UN Panel on Critical Energy Transition Minerals is a clear sign of the importance of this issue, and the recognition that governance gaps must be addressed to ensure that the extraction and processing of critical minerals underpinning the global transition to clean energy is done in a "sustainable, fair and just way". The Panel's recently published report offers a set of principles and recommendations to member states and other stakeholders ahead of COP29, and is expected to play a crucial role in shaping the global approach for the governance of energy transition minerals (ETM).

- Developing consistent and enforceable standards across the ETM value chain will require a concerted effort of international cooperation. The OECD's Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas has operated as the de facto international standard, and has been incorporated into regulations in Europe, the United States, Central Africa, and the Middle East, as well as in market and exchange requirements in Europe and Asia.

- Going beyond the development of industry standards and voluntary frameworks, an essential step for responsible ETM value chains is the harmonisation of regulations and development of binding agreements that prevent regulatory arbitrage. A significant development in this regard is the EU Critical Raw Materials Act that recently came into force. The Act makes an emphasis on sustainable sourcing, recycling and the circular economy.

- The global governance architecture of ETMs should enable resource-rich countries in the Global South to benefit equitably from the global energy transition, within a planetary justice framework.

- Governments can ensure that local communities are actively involved in decision-making processes, leading to more transparent and accountable governance of ETM resources. For example, "free, prior, and informed consent" is a common requirement for human rights protections.

- Specific financial incentives for research, development and deployment of innovative materials and processes throughout the ETM value chain (e.g., non-toxic extraction methods and mineral recycling technologies) in the form of tax exemptions, subsidies or grants are also important.

# 10 Public's acceptance of (or resistance to) climate policies crucially depends on perceptions of fairness

**KEY MESSAGES**

- Perceived fairness is a central determinant of acceptance or resistance to climate policies. Resistance to climate policies is shaped by structural factors, including socio-economic conditions and cultural identities. But policy design aspects that are sensitive to perceptions of fairness can increase the public's acceptance of the measures proposed. Overcoming resistance requires an understanding of the political economy and the interests of different groups.
- Inclusive and bottom-up processes of decision-making also help to overcome resistance. Success depends on developing policies that balance the citizens' and industries' interests while considering specific socio-economic fragilities.
- Ignoring or disregarding citizens' needs will continue to foment resistance that hinder effective climate policies. Failing to understand motives, ignoring the broad spectrum between acceptance and resistance, or conflating all forms of political opposition with crude climate denial is misguided and unhelpful.

A successful climate transition, in which private consumption and local adaptation are targeted, will need policies that do not conflict with the values and sentiments of impacted populations. Without public support, resistance will hamper urgent climate action. Failure to understand resistance will result in backlash, political opposition, social mobilisation and even civil unrest.

There is a growing evidence base on acceptance and resistance to climate policies showing multiple social factors that shape these reactions, including individual beliefs, social norms, cultural identities, and economic conditions, as well as specific types of policy design. Country-specific political-economic factors are also crucial elements for the success of climate policies. Fairness is a central determinant of acceptance and resistance: One review found perceptions of fairness to be the strongest determinant out of 15 factors evaluated. Perceived unfair distribution of economic costs, job security, cultural identity and social justice concerns resulting from climate policy can result in resistance (Figure 9). Public support for low-carbon energy transitions will always be challenged as long as corruption and unfair practices remain unaddressed. New taxes and the removal of subsidies often face resistance. Public support for such policies dwindles further when concerns about distribution and income inequality are high, as people are wary of unfairly bearing additional economic costs. But if the revenues or public savings are used for improving well-being or reducing inequality or even for environmental measures, the measures can become more acceptable (Figure 10). Fairness involves the recognition of negative impact by the countries and industries. The climate transition often overlooks local needs and aspirations that will cause short-term costs for some groups. Planned relocations are an example of adaptation measures that can

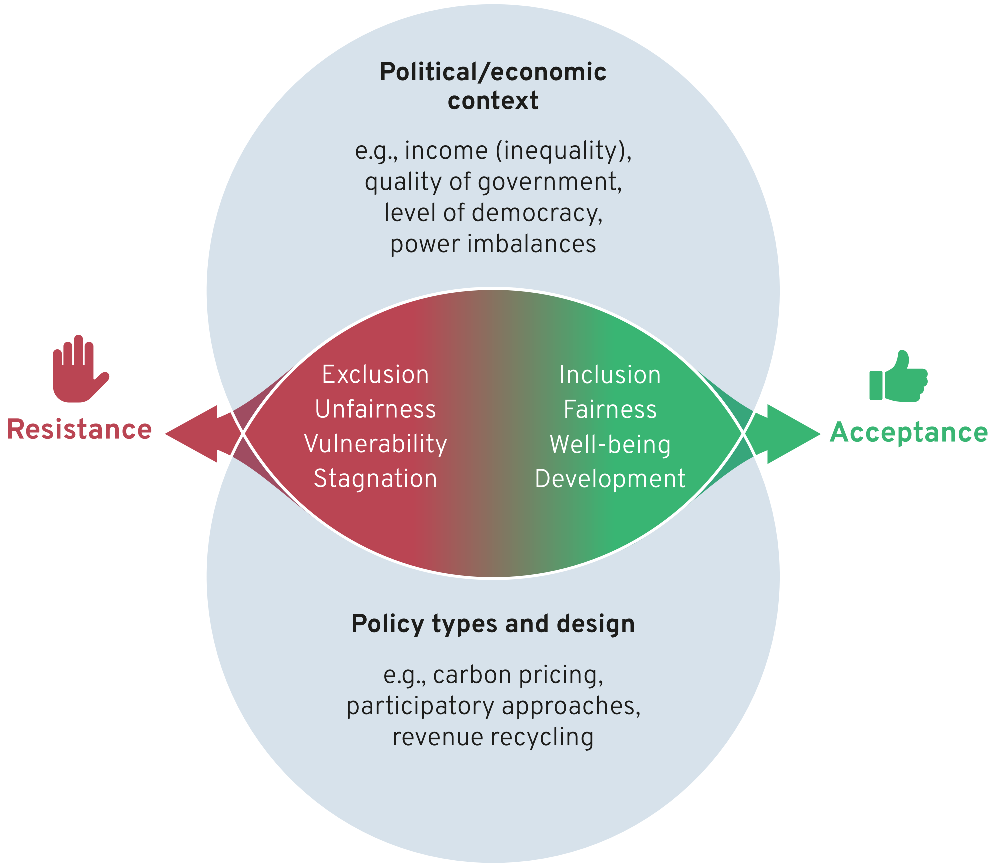


**Figure 10. Interaction factors leading to climate policy resistance or acceptance.** The interaction between political-economic contexts and policy designs can either lead to exclusion, injustice and vulnerability – resulting in popular resistance – or to inclusion, fairness and development – resulting in popular acceptance.

face strong resistance, especially when introduced without attention to the effects on social networks and livelihoods.

Motives for policy resistance can be culturally understood and depend on local needs and aspirations, yet this is often overlooked in international debates. Policies that consider the interests of influential social and industrial groups are key to reconciling success with fairness. In Indonesia, auto and motorcycle lobbying groups have prevented the withdrawal of fuel subsidies. In Ghana, fishing groups have done the same for kerosene subsidies, and labour unions have advocated for public transport fare increase exemptions. But citizens who lack political power can adopt "quiet resistance" through false compliance or foot-dragging to undermine policies they do not believe in.

Failing to understand the underlying motives and ignoring the broad spectrum between acceptance and resistance is unhelpful for implementing effective climate policies. Similarly, conflating opposition to specific policies (due the negative consequences experienced by a given constituency) with "climate change denial" are all unhelpful. Resistance is not inherently negative; it can provide a political voice to marginalised groups that lack the power to influence policy through democratic means. In countries with limited democratic processes, everyday forms of resistance can introduce alternative climate action paths and highlight local needs and aspirations often overlooked by the mainstream climate political agenda. Political resistance can be seen as another form of political participation. Recognising and using this resistance to highlight overlooked needs can lead to more effective policymaking. Without considering citizens' needs, resistance will continue to hinder transformative climate laws and policies.

Moreover, it is worth noting that there is a "perception gap" between what most people think others are willing to sacrifice to mitigate climate change: Global studies show that nearly 70% of people are willing to allocate 1% of their income to climate action, and almost 90% want more government efforts. Inclusive, democratic, bottom-up approaches and processes that involve local communities will help to overcome resistance. Success depends on policymakers balancing social and industrial interests while considering specific socioe-conomic fragilities derived from past economic and political reforms.

**POLICY IMPLICATIONS**

- Highlighting concrete processes for inclusive and participatory mechanisms, such as climate citizen assemblies, involving experts and diverse stakeholders, can increase the legitimacy and acceptability of climate policies. A focus on identifying and agreeing on fair pathways to the energy transition can foster effective collaboration and grant legitimacy to mitigation and adaptation policies.

- Policy design aspects can also shape the level of acceptability. Clearly communicated plans about how the revenue or savings (from a new tax or a removed subsidy) will be used for the public's benefit can make the policy more acceptable. Other aspects of policy design that can be deployed for increasing acceptability include packaging multiple policy instruments, and carefully sequencing and timing the policy's deployment. Tailored approaches that recognise specific needs and realities, and acknowledge diverse concerns, are needed to anticipate and overcome resistance from cultural and local factors.

- Developing and socialising economic plans to compensate for the losses that some will face (e.g., energy or transport costs) can be a crucial component for politically viable transition strategies. This might include the promotion of alternative employment opportunities and expanded safety nets.

- Visible actions to combat corruption and regulatory capture could contribute to raising perceptions of a fairer and more transparent environment.

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# Abbreviations

**AI** – Artificial Intelligence

**AMOC** – Atlantic Meridional Overturning Circulation

**COP** – Conference of the Parties

**CRD** – Climate-Resilient Development

**ENSO** – El Niño–Southern Oscillation

**ETMs** – Energy Transition Minerals

**FGCR** – Framework for Global Climate Resilience

**GDP** – Gross Domestic Product

**GGA** – Global Goal on Adaptation

**GHG** – Greenhouse Gases

**GMP** – Global Methane Pledge

**GST** – Global Stocktake

**HAP** – Heat Action Plan

**IPCC** – Intergovernmental Panel on Climate Change

**LDF** – Loss and Damage Fund

**ML** – Machine learning

**MRH** – Maternal and reproductive health

**MWP** – Mitigation Work Programme

**NAP** – National Adaptation Plan

**NCQG** – New Collective Quantified Goal on Climate Finance

**NDCs** – Nationally Determined Contributions

**SETS** – Social-Ecological-Technical Systems

**SST** – Sea Surface Temperature

**TFFF** – Tropical Forest Forever Fund

**UN** – United Nations

**UNDRR** – Nations Office for Disaster Risk Reduction

**UNFCCC** – United Nations Framework Convention on Climate Change

**WMO** – World Meteorological Organization

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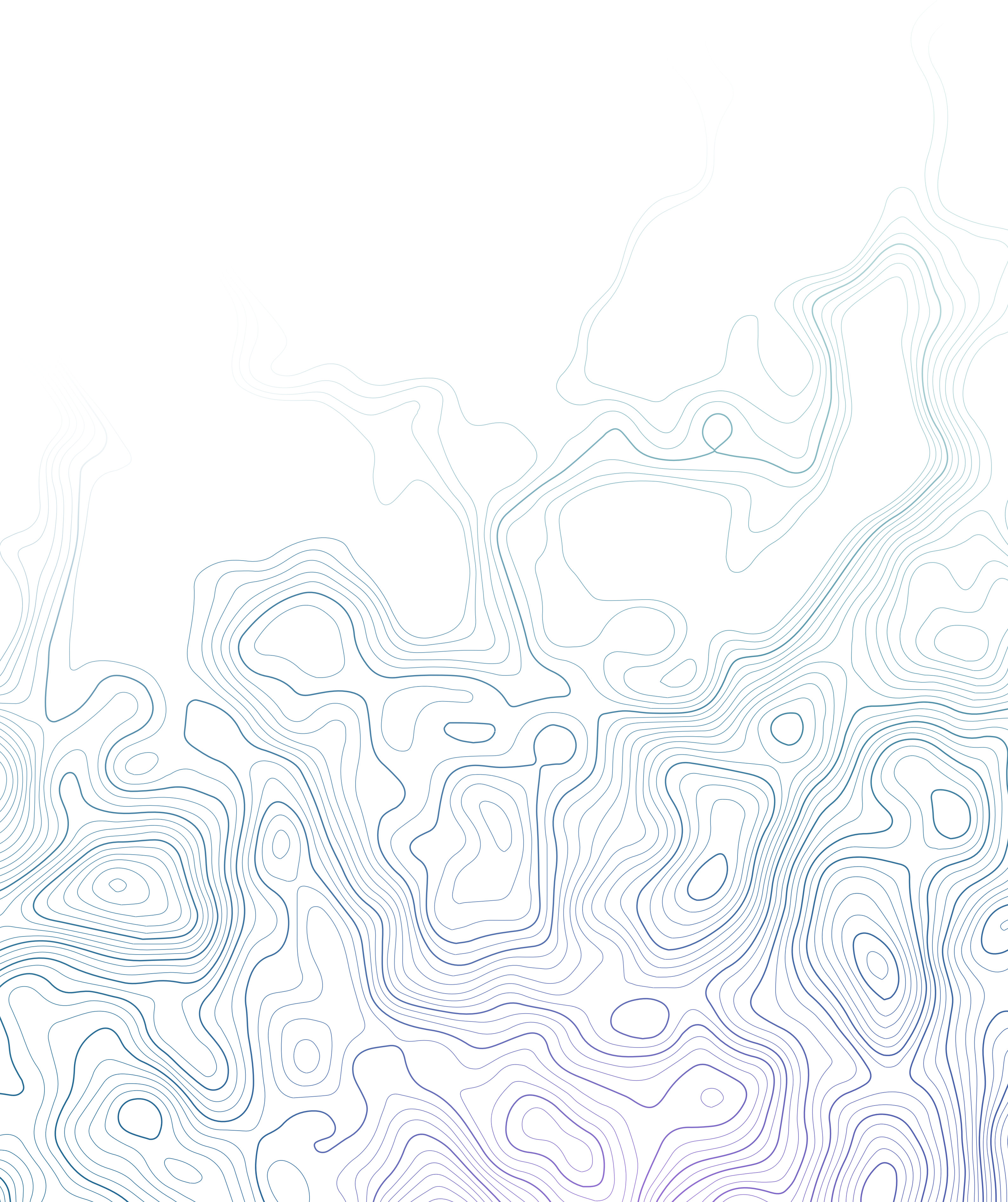

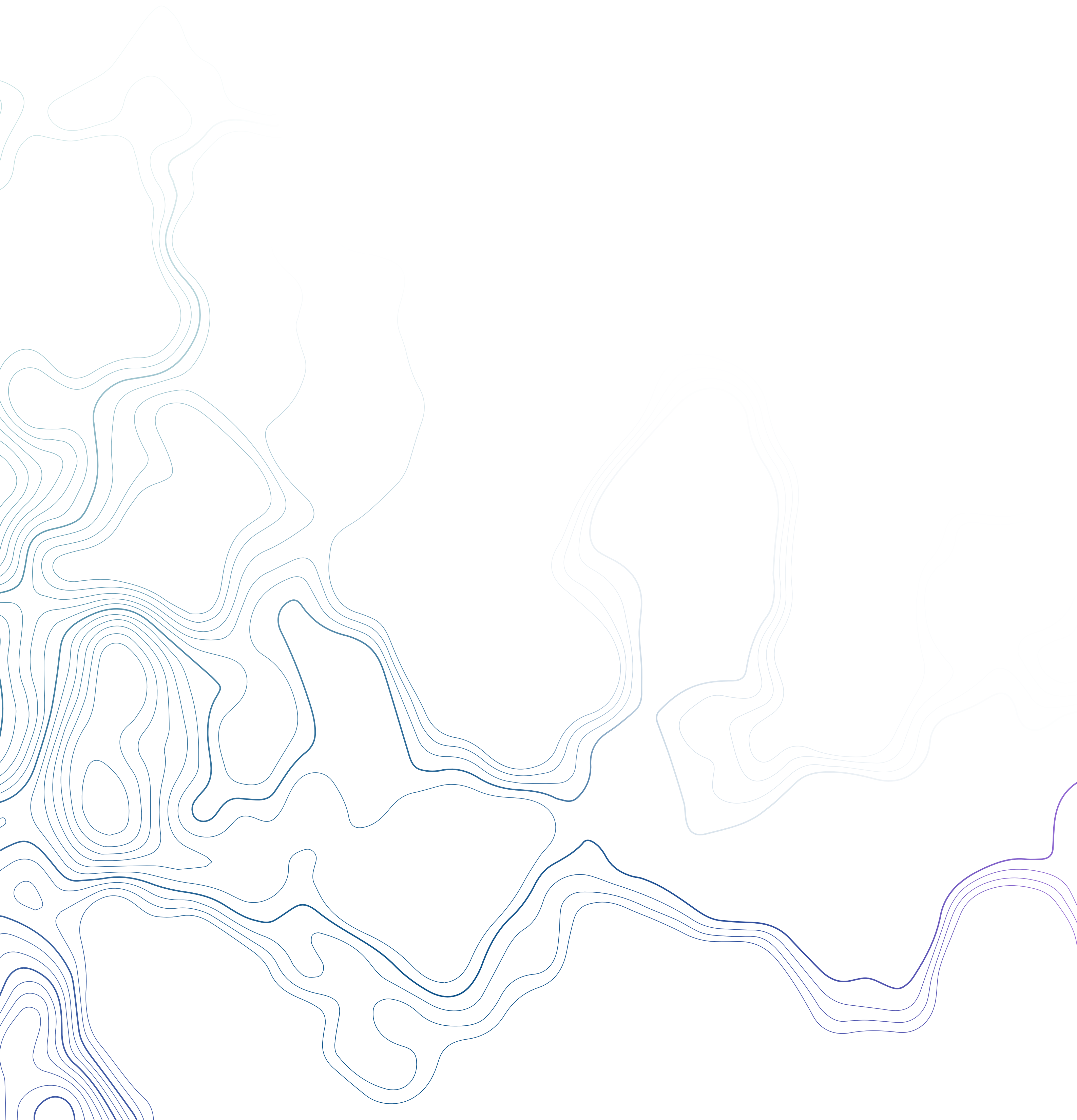

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