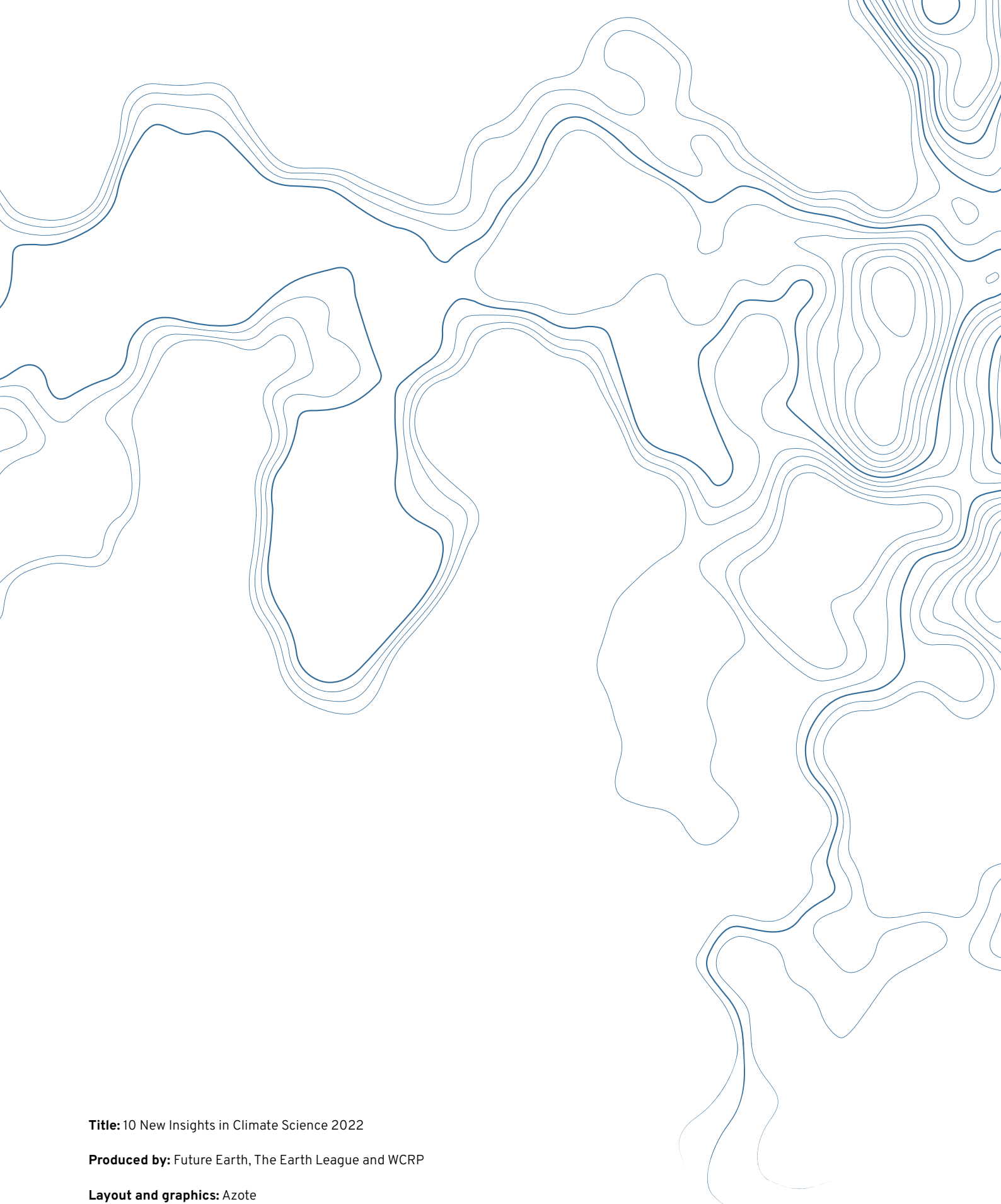


10 | NEW INSIGHTS IN CLIMATE SCIENCE

2022



Title: 10 New Insights in Climate Science 2022

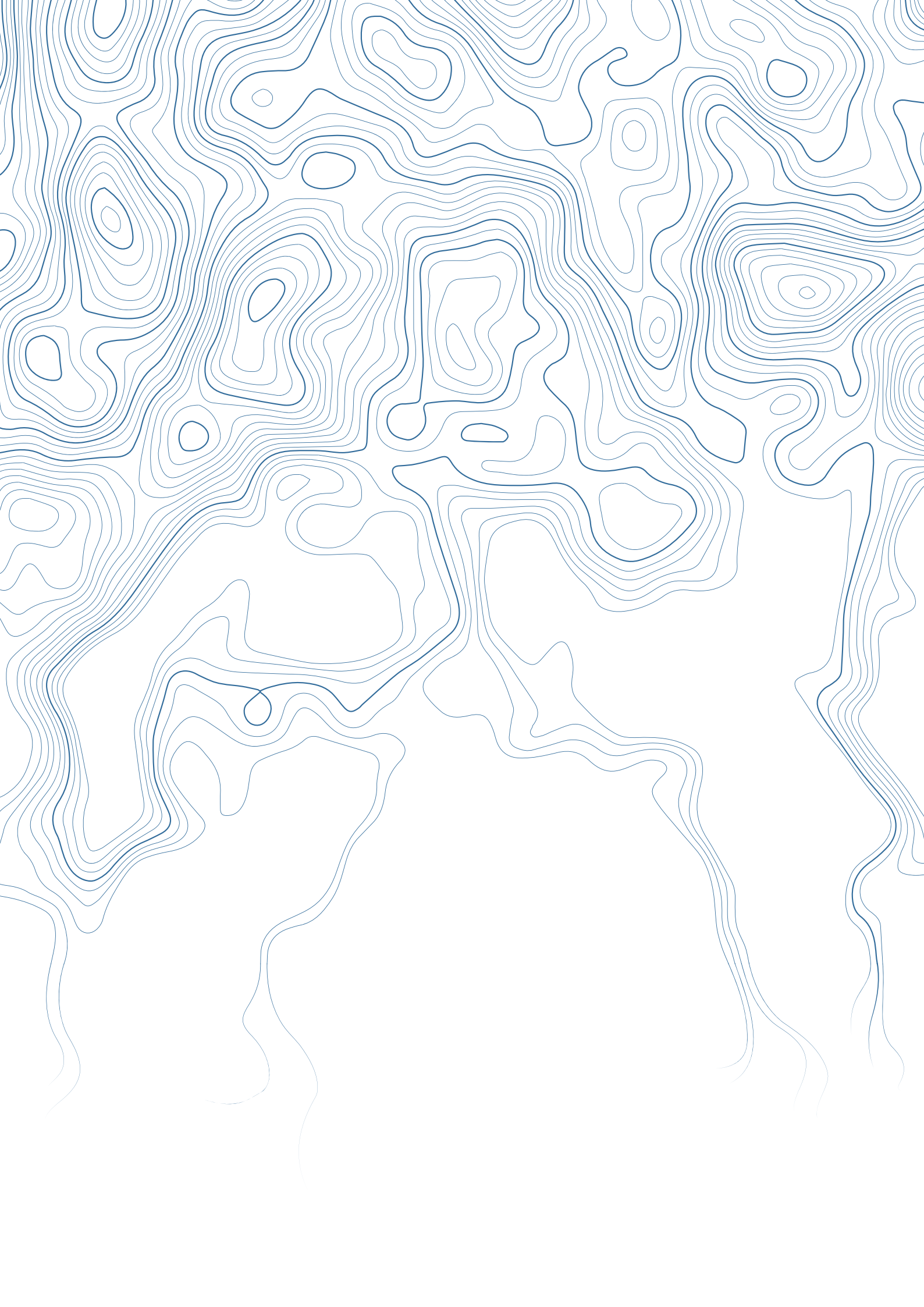
Produced by: Future Earth, The Earth League and WCRP

Layout and graphics: Azote

Printed on recycled, FSC-certified paper.

Cite this report as: Future Earth, The Earth League, WCRP (2022). 10 New Insights in Climate Science 2022. Stockholm

<https://doi.org/10.5281/zenodo.7228926>



EXECUTIVE SUMMARY

- 1. Questioning the myth of endless adaptation:** The potential to adapt to climate change is not limitless: people and ecosystems in different places across the world are already confronted with limits to adaptation, and if the planet warms beyond 1.5°C or even 2°C, more widespread breaching of adaptation limits is expected. Hence, adaptation efforts cannot substitute for ambitious mitigation.
 - 2. Vulnerability hotspots cluster in ‘regions at risk’:** Vulnerability hotspots – areas with the highest susceptibility to being adversely affected by climate-driven hazards – are home to 1.6 billion people, a number projected to double by 2050. The report identifies vulnerability hotspots in Central America, the Sahel, Central and East Africa, the Middle East, and across the breadth of Asia.
 - 3. New threats on the horizon from climate-health interactions:** Climate change is adversely impacting the health of humans, animals and entire ecosystems. Heat-related mortality, wildfires affecting our physical and mental health, and growing risks of outbreaks of infectious diseases are all linked to climate change.
 - 4. Climate mobility – from evidence to anticipatory action:** The rising frequency and intensity of extreme weather events related to climate change, as well as its slow-onset impacts, will increasingly drive involuntary migration and displacement. These impacts can also render many people unable to adapt by moving out of harm's way. Hence, anticipatory approaches to assist climate-related mobility and minimise displacement are essential in the face of climate change.
 - 5. Human security requires climate security:** Climate change exacerbates existing vulnerabilities in human security (caused by governance and socioeconomic conditions), which can lead to violent conflict. Effective and timely mitigation and adaptation strategies are required to strengthen human security and, by extension, national security. These must be pursued in parallel with concerted efforts to provide for human security to reduce the risks of increasing violent conflict and promote peace.
 - 6. Sustainable land use is essential to meeting climate targets:** Enhancing yields via sustainable agricultural intensification with integrated land management should replace further expansion into natural areas, providing climate solutions, food security and ecosystem integrity. However, as the planet continues to warm, those land system co-benefits are less likely to hold.
 - 7. Private sustainable finance practices are failing to catalyse deep transitions:** “Sustainable finance” practices in the private sector are not yet catalysing the profound economic transformations needed to meet climate targets. This reflects the fact that these are mostly designed to fit into the financial sector’s existing business models, rather than to substantially shift the allocation of capital towards meaningful mitigation.
 - 8. Loss and Damage – the urgent planetary imperative:** Losses and damages are already widespread and will increase significantly on current trajectories, making it imperative to advance a coordinated global policy response. Deep and swift mitigation and effective adaptation are necessary to avert and minimise future economic and non-economic losses and damages.
 - 9. Inclusive decision-making for climate-resilient development:** Decentring and coordinating decision-making across scales and contexts, while prioritising empowerment of a broad range of stakeholders, are key ways for climate action to be more effective, sustainable and just, as well as necessarily more reflective of local needs, worldviews and experiences.
 - 10. Breaking down structural barriers and unsustainable lock-ins:** Transformative change towards deep and swift mitigation is impeded by structural barriers that arise from the current resource-intensive economy and its vested interests in maintaining the status quo. Integrating justice and equality across global agreements, decision-making processes, production-consumption arrangements, de-risking decarbonisation investments and fundamentally revising how progress is measured would strengthen climate action and redress ingrained and persistent injustices.
-



CONTENTS

	Executive summary	5
	Introduction	9
	Insight 1 Questioning the myth of endless adaptation	13
	Insight 2 Vulnerability hotspots cluster in ‘regions at risk’	17
	Insight 3 New threats on the horizon from climate–health interactions	19
CONTENTS	Insight 4 Climate mobility: from evidence to anticipatory action	22
	Insight 5 Human security requires climate security	25
	Insight 6 Sustainable land use is essential to meeting climate targets	28
	Insight 7 Private sustainable finance practices are failing to catalyse deep transitions	32
	Insight 8 Loss and Damage: the urgent planetary imperative	35
	Insight 9 Inclusive decision-making for climate-resilient development	37
	Insight 10 Breaking down structural barriers and unsustainable lock-ins	40
	Acknowledgements	43

INTRODUCTION

Recent years have been dominated by compounding global crises. Just as the world appeared to be emerging from the worst of the COVID-19 pandemic, Russia's invasion of Ukraine sent shockwaves through global markets and supply chains, threatening food security, and reshaping the energy portfolios. In the long term, the political and economic impacts of this shock are likely to further incentivise the transition away from fossil fuels. However, in the short term at least, these crises have moved attention away from climate action, pushing aspirations for a green recovery to a lower priority in national and international politics, and even leading to new permissions for oil drilling and reigniting coal power plants once again.

New evidence on climate risk suggests that multiple climate tipping elements could be triggered if global temperature rises beyond 1.5°C. Current policies point towards a temperature increase of 2.8°C,* which entails additional risks for multiple tipping elements of central importance to Earth system stability**.

This report presents 10 salient insights from climate change research, stemming mainly from literature published in 2021 and 2022. Taken together they reveal the complexities of the interactions between climate change and other risks, such as conflicts, pandemics, food crises and underlying development challenges – pushing us ever closer to breaking past the socioecological limits within which people and ecosystems must remain to thrive. The purpose of the publication is not only to identify the mounting impacts of climate change and multiple barriers to climate action, but also to highlight implications and recommendations in support of a way forward for negotiators, policymakers and other relevant actors.

Rapid mitigation is more urgent than ever. As global temperatures rise, adaptive responses become less effective. Societies and ecosystems start hitting limits to adaptation (Insight 1), beyond which further losses and damages can be expected (Insight 8). “Soft” limits to adaptation can be overcome through policy actions that facilitate new technologies, institutions and social structures. But there are also “hard” limits, such as the direct threat to life posed by the combination of extreme heat and humidity or rising sea levels threatening communities in low-lying coastal regions. Effective syncing of ambitious mitigation and adaptation agendas, in light of emerging science on limits to adaptation, is needed in order to avert and minimise further losses and damages.

* Assuming a continuation of current policies, global warming this century will reach 2.8°C (range 2.3–3.3°C) with 66% probability (UNEP, Emissions Report Gap 2021) <https://www.unep.org/resources/emissions-gap-report-2021>

** Armstrong McKay, D.I., et al., (2022). Exceeding 1.5°C global warming could trigger multiple climate tipping points. *Science*, 377, eabn7950. doi:10.1126/science.abn7950

Vulnerability hotspots emerge at the confluence of increasing climate-driven hazards and increasing sensitivity in social and economic systems (Insight 2). In these contexts, adaptive capacity is weakest for marginalised communities, particularly in the low-to-middle income countries due to inequality and insufficient resources. Biodiversity loss, pollution and climate change conform into a “triple planetary crisis” outlined by the UN, amplifying the challenges relating to food, water, energy security, and human health and safety (Insight 5). Human insecurity and conflict, insidiously intertwined, exacerbate climate change in a variety of ways, with deep and long-lasting impacts far beyond the battlefields. Climate change-related health impacts are projected to increase with additional warming, with risks to physical and mental health (Insight 3). Animal and plant health are also heavily impacted. Resilience-building requires enhanced monitoring and surveillance, early warning and response systems, and coordinated action across sectors.

Climate and weather factors are driving involuntary migration and displacement, which will increase in the coming decades, due to increasing impacts of climate change (Insight 4). But the links between human mobility and climate change are notoriously complex, and the ability or willingness to move even in the face of climate risks is not a given. Implementing anticipatory approaches in humanitarian and development programmes should be a priority.

Integrated land management can provide climate solutions with multiple potential co-benefits for people and ecosystems, but as global warming increases, our current assumptions of what land can do for us become less certain (Insight 6). The priority of policy actions should stay focused on reducing GHG emissions from land-based activities by discouraging conversion of natural ecosystems, as well as reducing methane and nitrous oxide emissions, particularly from livestock.

Mobilising private finance to align with sustainable activities is a crucial step towards decarbonising the economy. Unfortunately, the so-called sustainable practices in the private finance sector are not yet catalysing the deep and rapid transformations needed to meet climate targets (Insight 7). The sector’s sluggish recognition of corporate greenwashing is connected to the data gaps in climate disclosure and metrics, and an absence of analytical tools for supporting sustainable financial practices. Active engagement by large institutional investors, on the other hand, is one area showing promising outcomes. Looking ahead, governance needs to be reformed – and public policy strengthened – to ensure private capital flows into climate solutions at the required scale and pace.

Loss and Damage (L&D) is one of the most politically contentious issues in current climate diplomacy, as it implies the responsibility and potential liability for harm inflicted by climate change impacts – an issue that will grow as those impacts accelerate and intensify (Insight 8). With no progress towards an L&D financing mechanism at COP26, this will no doubt be a critical issue at COP27. But climate politics and decision-making are not limited to the UN climate summits. Decisions are taken every day at national, corporate and community levels, which cumulatively determine the response of societies to the climate crisis. Recent research provides additional evidence that more inclusive decision-making can lead to more effective climate-resilient development, yet it is still commonly implemented in a perfunctory manner (Insight 9).

Structural obstacles have created lock-ins across policies, industries and societies that drive resource extraction and emissions ever upwards (Insight 10). Positive change can be accelerated through progressive social movements, new forms of governance, and appropriate policy instruments. Across the world, societies are already suffering the impacts of climate change. But we can avoid even worse conditions in the future if we have the political will to embrace new economic paradigms that can unlock our potential to achieve decarbonisation.

All statements in this summary report are based on the following article and the references provided therein: Martin et al. (2022): Ten New Insights in Climate Science 2022. *Global Sustainability*.





THE INSIGHTS

1 Questioning the myth of endless adaptation

KEY POINTS

- Limits to adaptation are being breached already in different places across the world. Climate adaptation will become increasingly difficult as we approach 1.5°C or even 2.0°C above pre-industrial temperatures.
- Existing adaptation efforts are falling short of adequately reducing risks from past, current and future climate change, leaving the most vulnerable particularly exposed to climate impacts.
- Adaptation cannot substitute for ambitious mitigation efforts. Even effective adaptation will not avoid all losses and damages, and new limits to adaptation can emerge in the shape of conflicts, pandemics and pre-existing development challenges. Deep and swift mitigation is critical to avoid widespread breaching of adaptation limits.

INSIGHT EXPLAINED

Humans have a remarkable capacity to adapt, but as the planet continues to warm, we will be increasingly confronted with intolerable impacts of climate change to which people and ecosystems are not able to adapt. In other words, there are limits to adaptation. So-called “soft” limits to adaptation denote contexts where adaptation options may exist but are not currently available due to, for example, insufficient access to finance, weak governance structures, and lack of political will. Soft limits can be overcome through social, institutional or technological innovations and transformation. “Hard” limits refer to situations in which adaptive actions to avoid intolerable risks are no longer possible, such as extreme heat unbearable to the human body, or rising sea levels submerging coastal communities.

Limits to adaptation are deeply contextual: they are shaped by place-specific climate risks and socioecological resilience, as well as the nature and

distribution of existing adaptive efforts. Exceeding adaptation limits can lead to irreversible losses and damages (see Insight 8), an experience that can fundamentally change communities. Crucially, limits to adaptation are dynamic: they evolve in response to external changes – such as the rising temperatures – but also due to the socioecological interplay between current limits and societies’ response to them. Hence, “new” limits to adaptation can emerge as the socioecological system approaches or breaches current limits.

Limits to adaptation are most frequently reported for vulnerable groups in low-income regions and are especially acute for Small Island States and low-lying coastal zones more generally. The distribution of investments in adaptation reflects underlying socioeconomic inequalities, reinforcing patterns of vulnerability (Insight 2). Existing adaptation efforts, for example in food systems and infrastructure, are insufficient to adequately reduce risks associated with current and future climate impacts. But even

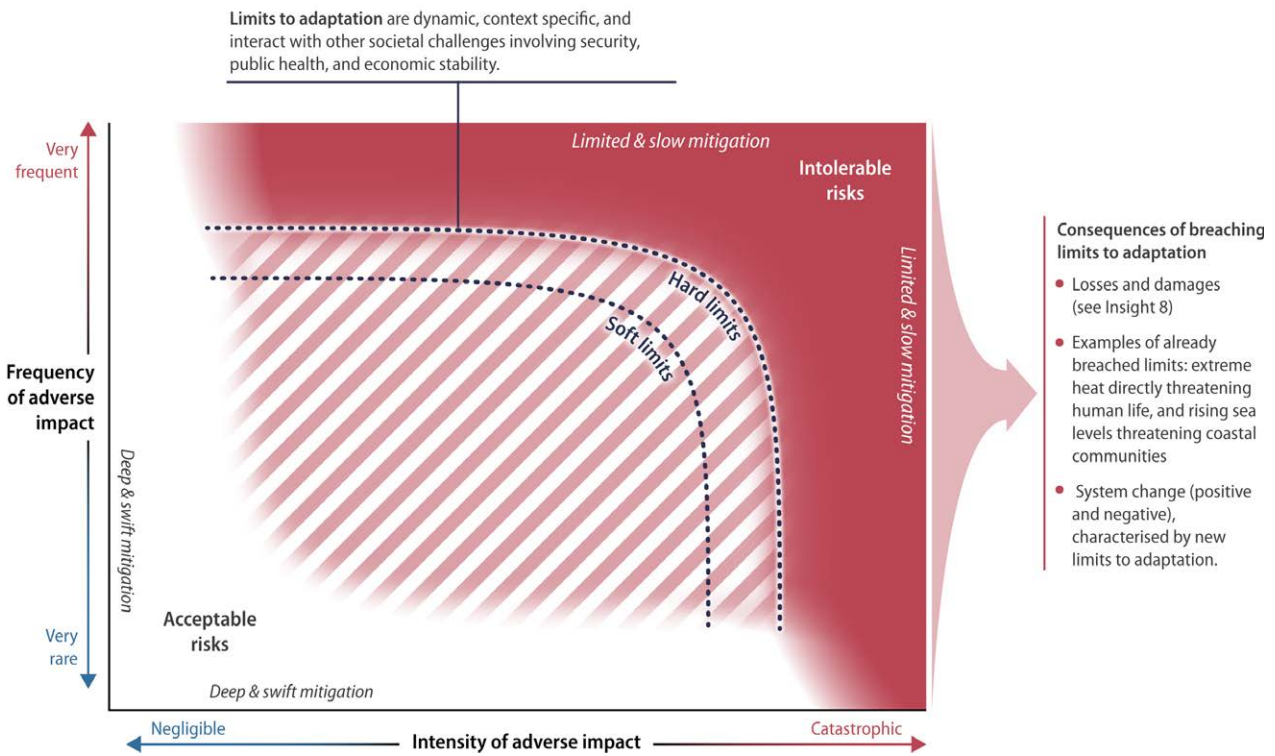


Figure 1. Conceptual representation of limits to adaptation, including soft and hard limits. The visualisation shows deep and swift mitigation is critical to avoid breaching adaptation limits. Adapted from Dow et al. (2013)*.

with the right support to implement available adaptive strategies, limits to adaptation will be unavoidably breached in some instances.

Research and policy literature converges on a need for a fundamental change in how we pursue climate adaptation and deal with adaptation limits. Transformative change will be necessary to overcome the soft limits to adaptation and avoid reaching hard limits, and even to create opportunities for climate-resilient development. This will require addressing structural political and economic conditions that exacerbate vulnerability to the impacts of climate change (Insight 2), as well as strengthening inclusive decision-making institutions (Insight 9).

We are already breaching adaptation limits, and adaptation will only become more difficult as we approach 1.5°C or even 2°C average global warming. This implies that the remaining available adaptive actions will be even more demanding, which, in turn, can create more social stress and further risks. We cannot endlessly adapt to climate change. Therefore, adaptation is not a substitute for mitigation. Deep and swift mitigation efforts are critical to avoid the widespread breaching of limits to adaptation.

IN FOCUS: COMPLEXITY OF INTERACTING RISKS

The interaction of climate change with other risk drivers creates vicious circles. Our ability to adapt is limited by uncertainty: about climate risks and future actions, and about the complex systems in which we live. What is effective today may lose efficacy due to system dynamics that are difficult to foresee. As witnessed in recent years, climate change interacts with other risk drivers, for example conflicts and pandemics, as well as pre-existing development challenges, resulting in system effects such as food shortages and rising poverty and inequality. These, in turn, may give rise to new limits to adaptation, creating a vicious circle of compounding impacts. Each factor can stress social orders and load pressure on individuals, producing maladaptive decisions that render communities – and the ecosystems they depend on – more inflexible and fragile. Given the complex nature of socioecological systems, some of these maladaptive outcomes emerge in unpredictable ways.

* Dow, K., et al., (2013). Limits to adaptation. *Nature Climate Change*, 3(4), 305–307. doi:10.1038/nclimate1847

IMPLICATIONS AND RECOMMENDATIONS

Climate negotiators and decision makers at all levels – international, national and local – need to:

- Pursue deep and swift mitigation efforts, in order to avoid a future in which people and ecosystems are pervasively confronted with limits to their adaptation.
- Develop ambitious adaptation plans – increasingly catastrophic climate change impacts mean that transformational change is required to enable the necessary level of adaptation.
- Tailor adaptation strategies to local contexts, and place more focus on reducing the vulnerability of the most marginalised communities.
- Overcome soft limits to adaptation through targeted financing and more effective governance structures – leading to desired social, institutional or technological change.
- Adopt an agile approach to adaptation – recognising that adaptation limits dynamically evolve as loss and damage impacts livelihoods and environments.



2 Vulnerability hotspots cluster in ‘regions at risk’

KEY POINTS

- Approximately 1.6 billion people live in vulnerability hotspots, a number projected to double by 2050. Climate-driven hazard mortality is 15 times higher in hotspot countries than in the least-vulnerable countries.
- Vulnerability – the susceptibility to be adversely affected by climate-driven hazards – is a product of structural inequality in human–environmental systems. It clusters in major “regions at risk”: in parts of Central America, Asia and the Middle East, and in Africa across the Sahel, Central and East Africa.
- Communities in these regions at risk are increasingly exposed to climate change and climate-related hazards, where resilience (physical, ecological and socioeconomic) decreases with worsening levels of inequality, state fragility and poverty.
- Hotspots of vulnerability in the Arabian Peninsula and Central Asia are related to loss of habitats and biodiversity decline, reducing the ability of ecosystems to mitigate climate change and provide ecosystem services and resources, therefore affecting the adaptive capacity of marginalised groups.

INSIGHT EXPLAINED

Although humans often act as if we have a unique and controlling position in the natural world, the health of our societies is intertwined with natural systems. Bit by bit, climate change and worsening climate extremes are chipping away at the resilience of physical, ecological, socioeconomic and sociocultural systems, putting people and livelihoods at risk. The worst impacts are felt in places with pre-existing, systemic vulnerability linked to poverty, forced migration, inequality and state fragility.

According to global assessments of vulnerability that combine socioeconomic factors alongside climate hazard risk, an estimated 1.6 billion people live in regions that are in the highest categories of vulnerability, where populations are predicted to double by 2050. Vulnerability assessments can take many forms: here we combine indicators for sensitivity (such as poverty, health and food security indicators), adaptive capacity (such as gender

parity, state fragility and biodiversity protection) and degree of exposure of different regions to multiple climate hazards, and we see vulnerable regions emerging globally (Figure 2). Regional hotspots are clustered in Central America, Asia, the Middle East and several regions of Africa: the Sahel, Central and East Africa. In the most vulnerable countries, mortality from floods, drought and storms is 15 times higher than in the least-vulnerable countries.

Each hotspot has its unique economic, ecological and political conditions. Parts of Central Africa and the Middle East, for example, have been associated with high levels of state fragility. Meanwhile, displacement, coupled to low livelihood security, contributes to vulnerability in countries in Central Africa, East Africa and West Africa, and Southwest Asia. Gender inequality exacerbates vulnerability to significant climate-driven natural hazards, since women are already exposed to disproportionate risks to health and income through structural disadvantage.

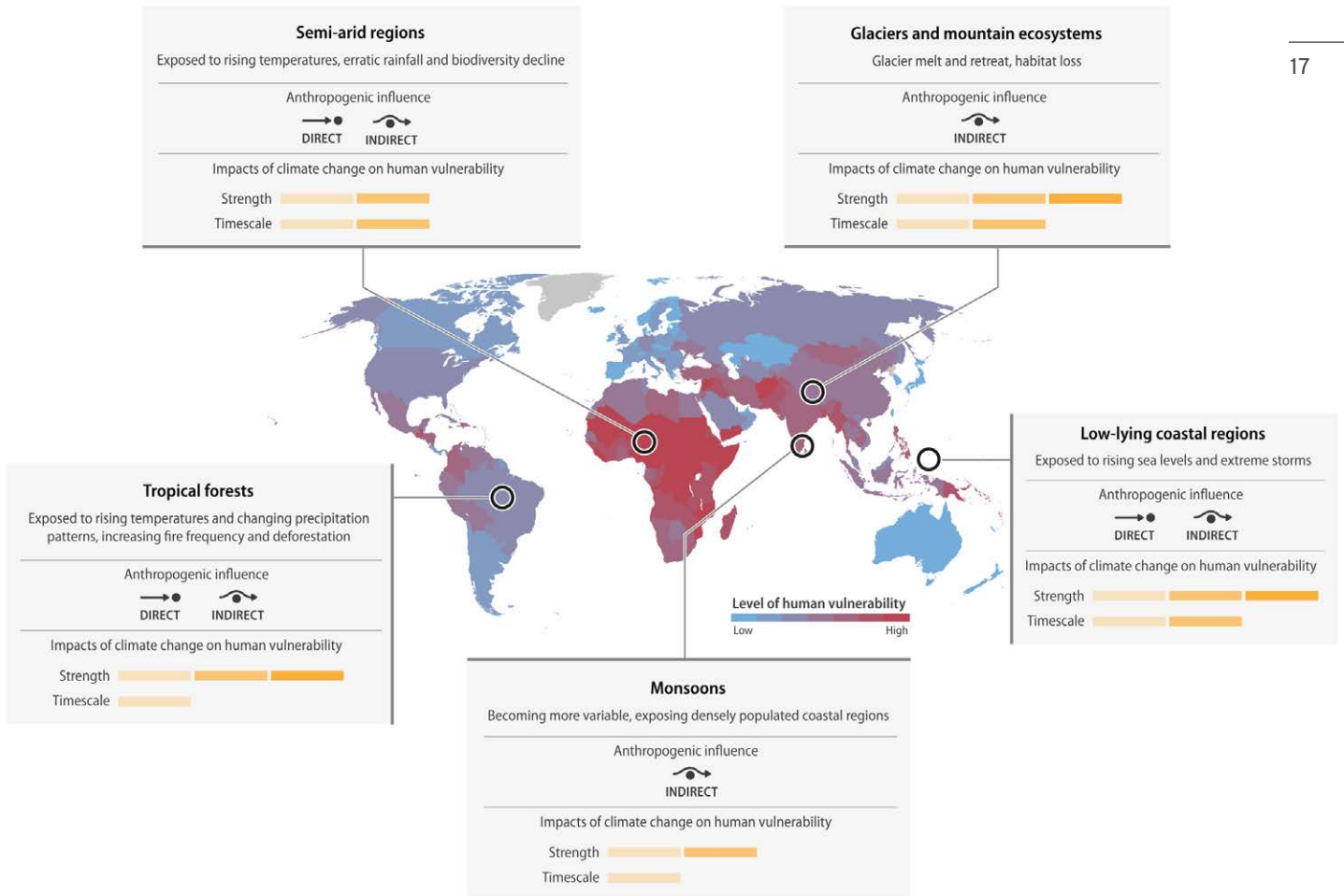


Figure 2. Schematic diagram illustrating systematic human vulnerability on a scale of seven vulnerability categories (adapted from Birkmann et al., 2021)*. It also highlights climate system components and ecosystems most relevant to human vulnerability from direct (e.g. deforestation) and indirect (e.g. global warming due to GHG emissions) anthropogenic influence. Their impact is assessed qualitatively based on their temporal proximity and the strength of their impacts on human vulnerability (adapted from Schellnhuber et al., 2016)**.

Going forward, as climate threats intensify, so will threats to human systems – particularly in the identified vulnerable regions (Figure 2). More variable patterns of tropical monsoon systems in South America, India and Southeast Asia, along with the slowdown of the Atlantic Meridional Overturning Circulation (AMOC), could lead to weather extremes that further expose human vulnerability in densely populated coastal areas.

The close connection between socioeconomic drivers of vulnerability and human livelihoods is determined by access to resources and basic needs, such as food and water supplies. Habitat degradation is putting many ecosystems at high

risk of structural and dynamic change, reducing their climate mitigation capability. It also decreases the ecosystem services and resources those habitats can provide, threatening the adaptive capacity of marginalised groups.

A widespread climate-induced biodiversity loss is expected in Central and South America, including the Andes, one of the most biodiverse regions in the world. This is driven by the combined pressures of human activities, ongoing warming and more erratic temperature and precipitation patterns. Many hotspots of biodiversity across tropical regions are expected to decline further.

* Birkmann, J., et al., (2021). Regional clusters of vulnerability show the need for transboundary cooperation. *Environmental Research Letters* 16(9), 094052. doi:10.1088/1748-9326/ac1f43

** Schellnhuber, H.J., et al., (2016). Why the right climate target was agreed in Paris. *Nature Climate Change*, 6(7), 649–653. doi:10.1038/nclimate3013

IN FOCUS: LOCALISED NATURAL RESOURCE VULNERABILITIES

Tropical rainforests in South America have experienced a large-scale loss of resilience since the early 2000s and could already be close to a critical threshold of dieback or potential shift towards a degraded state. Driven by climate change, forest degradation, increasing fire frequency and deforestation, ecosystem productivity in tropical rainforests has declined, and part of the Amazon region has become a net carbon source. Localised fire feedback and changing precipitation patterns amplify drought intensity and forest and carbon loss, decreasing resource availability for the livelihoods of local communities. With less forest, there is less water flowing back to the atmosphere, weakening

moisture recycling and making different types of droughts more likely.

Elsewhere, glacier retreat in the Himalayas threatens water supply, particularly under drought conditions. The Himalayas provide water for 1.3 billion people in the vicinity of 10 major river basins in Asia. Lack of water resources increases agricultural vulnerability to the changing climate, affecting the food security and health of large populations. Similar effects are observed in mountainous regions in Africa and South America, where agricultural production is highly sensitive to climate change, even in a 1.5°C world.

IMPLICATIONS AND RECOMMENDATIONS

At a global level, it is suggested that all parties to the UNFCCC:

- Address the different aspects of vulnerability to help alleviate soft limits to adaptation (see Insight 1): prioritise funds for climate-resilient development towards regional hotspots of vulnerability, where high systemic vulnerability combines with the severity of climate hazards.
- Strengthen resilience at scale through transboundary approaches (such as the Africa Adaptation Initiative) and anticipatory humanitarian actions (see Insight 4) that strengthen institutional capacities and create incentives for stronger collaboration within a vulnerable region where countries share common challenges.
- Urgently prioritise more robust international agreements to protect critical carbon sinks and biodiversity hotspots, particularly in vulnerable tropical regions.

At a national and local level, policymakers must:

- Put measures in place to ensure sustainable and equitable management of natural resources and biodiversity protection, to prevent further loss of ecosystem services.
- Address food security in drylands, by paying particular attention to the technological development of dryland crops, soil improvement and integrated water management.
- Pay special attention to water resource availability, a key driver of agricultural vulnerability in Africa, South and Southeast Asia, and South America, affecting the food security and health of large populations, in particular linking to child malnutrition.
- Treat gender inequality as a key consideration in interventions to reduce socioeconomic and political vulnerability.

3 New threats on the horizon from climate–health interactions

KEY POINTS

- Compounding and cascading risks due to climate change are adversely impacting human, animal and environmental health.
- Climate change is already responsible for close to 40% of heat-related deaths and every inhabited continent is experiencing increased heat-related mortality.
- Wildfires are increasing in frequency due to the combination of higher temperatures and drought, bringing short- and long-term physical and mental health impacts.
- Outbreaks of infectious diseases are likely to increase due to climate change.

INSIGHT EXPLAINED

Climate change has been described by the World Health Organization (WHO) as the single biggest health threat facing humanity. Research consistently reveals compounding and cascading risks of climate change on human, animal and environmental health. These risks have the potential to slow advances made in population health over the last decades and disrupt functioning health systems.

Climate change is already responsible for 37% of heat-related deaths globally (measured timeframe: 1991–2018) – with the burden likely exacerbated by recent 2022 heatwaves that exceeded temperature records. In the meantime, every inhabited continent is experiencing increased heat-related mortality. Most attribution studies likely underestimate the numbers of deaths, illnesses, hours of lost productivity, and adverse economic consequences. Some regions, such as mountainous areas, are newly experiencing heatwaves, with dire implications for their populations. The observed increase in “tropical nights” exposes more people to heat stress because of the reduction in cooling respite. Heat exposure

also results in adverse reproductive outcomes such as preterm birth, low birthweight, stillbirth and lower sperm production.

Infectious diseases are likely to increase due to climate change, especially waterborne and vector-borne diseases, as evidenced by increased childhood diarrhoeal disease being observed in some regions during extreme weather events. In addition to temperature-related changes in geographic range, large-scale outbreaks of infectious disease can affect local and global health from cascading pathways involving weather and climate events, population movement, land-use changes, urbanisation, global trade and other drivers. Increasing impacts are also observed among plants and animals, with attribution of climate change effects at national and local levels. For example, wildfires, extreme heat, drought and flooding events impact livestock health and production, fisheries and populations of wild animals. Increases in the spread and severity of animal and plant diseases can then affect food security and ecosystem functions. This risk has resulted in the increased use of pesticides and antimicrobials.

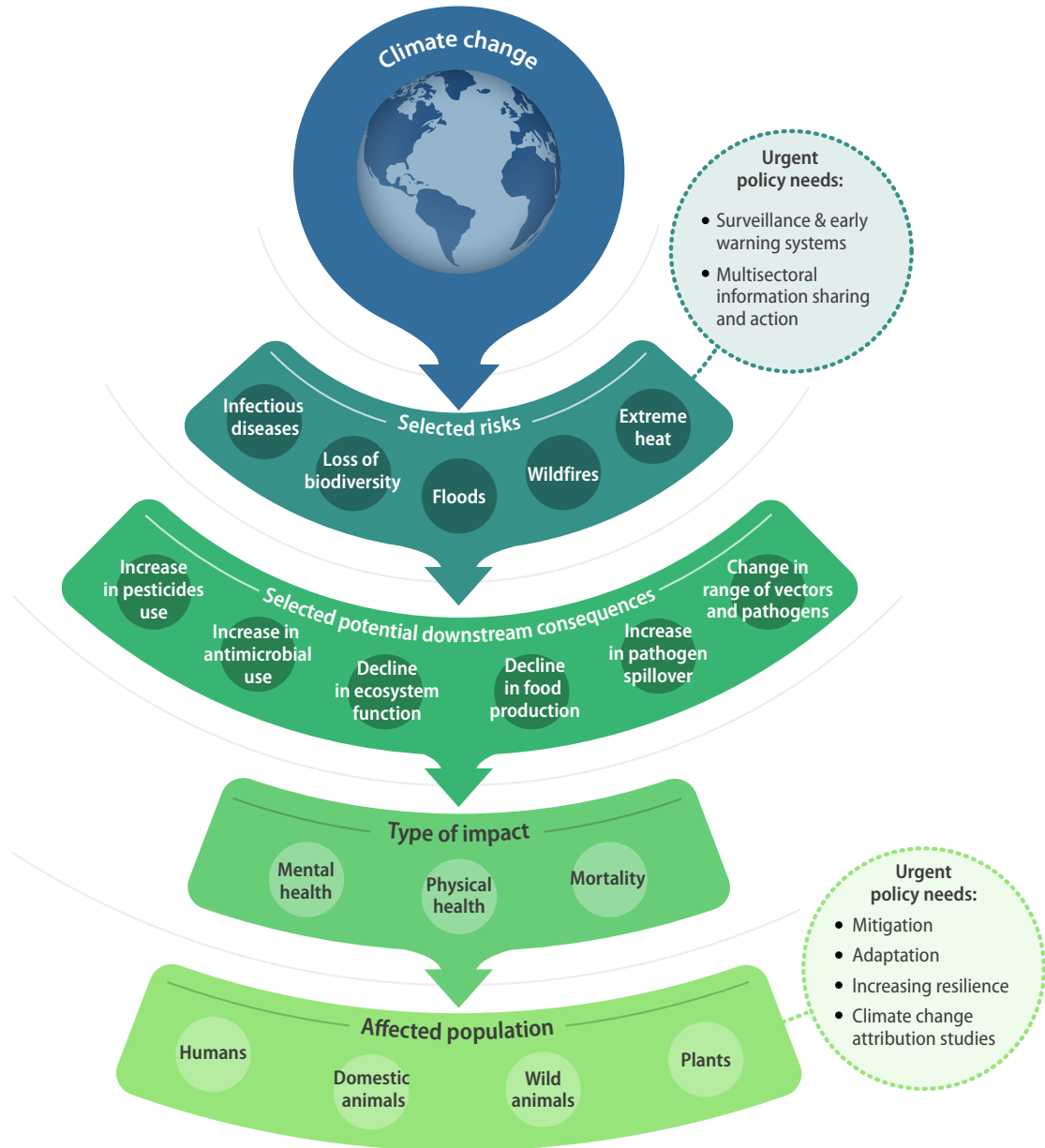


Figure 3. Urgent policy needs on selected risks and potential downstream consequences of climate change on health.

Climate change brings an increase in cross-species viral transmission risk, and zoonotic virus spillover and spread in humans is more likely, especially at high elevations, in biodiversity hotspots, and in areas of high human population density in Asia and Africa.

Significant numbers of lives can be protected by investing in early warning systems (relevant to extreme weather events, microbial transmission, and disease outbreaks and other health risks such as respiratory distress or toxicity), which should include monitoring and evaluation. To address the growing climate challenge, health systems need to become more resilient, addressing inequities to better manage complex and compounding hazards in a systems-based manner.

IN FOCUS: EXTREME HEAT AND WILD-FIRES, A CASCADING HAZARD

Extreme record-breaking temperatures in Europe in July 2022 led to wildfires raging throughout Spain, Portugal, France and the United Kingdom. Worldwide, the combination of higher temperatures and drought is increasing the number of wildfires with short- and long-term physical and mental health impacts. Wildfires contain ambient air pollution in the form of fine particulate matter (PM_{2.5}), which is more toxic, and brings greater health impacts, than exposure to comparable concentrations of other conventional air pollution particulates.

IMPLICATIONS AND RECOMMENDATIONS

At a global level, it is suggested that all parties to the UNFCCC:

- Improve understanding of how climate change is causing injuries, illnesses and deaths today to ensure mitigation and adaptation strategies take a multisectoral approach with health as a central motivation.
- Expand statistical monitoring related to health to help countries sufficiently track impacts on human, animal and environmental health (one health approach) and document progress towards health protection and resilience.
- Advocate improved microbial and disease surveillance, including from known, novel and antimicrobial-resistant pathogens.

At a national and local level, policymakers must:

- Build climate resilience and environmental sustainability into healthcare systems, and design broader policy tools that reflect the uncertainties of climate change impacts and development choices, and their varied effects on humans, animals, plants and ecosystems.
- Consider the current cost of climate inaction on human, animal and environmental health systems and re-examine budgets and financial incentives to ensure adequate investment in prevention and addressing vulnerabilities.
- Invest in early warning systems to save lives (see Insight 4 discussion on anticipatory humanitarian actions) and optimise information sharing from early warning systems across sectors so that threats can be detected early and sufficient action can be taken rapidly.
- Improve knowledge about the benefits of disaster preparedness and adaptation options that address inequities.
- Align sectoral action plans for shared interventions towards improved climate change mitigation and adaptation, health security, antimicrobial resistance, universal health coverage, biodiversity protection and wider sustainable development.
- Tackle inequities and increase resilience across population groups (See Insight 2) to be better prepared for complex and compounding hazards in a holistic manner, to effectively protect health and wellbeing.

4 Climate mobility: from evidence to anticipatory action

KEY POINTS

- Involuntary migration and displacement will increasingly occur due to climate change-related slow-onset impacts and the rising frequency and intensity of extreme weather events.
- Climate change and related impacts can also result in many people, particularly poor and marginalised communities, losing their capacity to adapt by moving away. However, others will choose to stay, despite facing increasing climate risks.
- Worldwide, there is a growing number of anticipatory humanitarian actions to assist climate-related mobility and minimise displacement – with early success stories.

INSIGHT EXPLAINED

The IPCC's 6th Assessment Report (IPCC AR6 WGII, 2022) stated unambiguously and with “high confidence” that human-induced climate change has impacted human mobility* patterns through changes in migration destinations and increasing displacement risks. The growing importance of climate-related impacts has also been highlighted by all leading international authorities on human mobility (International Organization for Migration, Internal Displacement Monitoring Centre, International Committee of the Red Cross). These dynamics are expected to be amplified as climate change impacts accelerate. For example, the recent World Bank Groundswell report provides a set of projections under different scenarios and identifies “hotspots” of internal migration in six world regions. It concludes that, in the absence of effective climate and development action, flows will accelerate between now and 2050 – concentrated in the poorest and most climate-vulnerable regions, especially in sub-Saharan Africa. On their high GHG

emissions scenario there are 91.9 million internal migrants more by 2050 than on the low emissions scenario (peaking at 1.4°C–2.6°C and 0.4°C–1.6°C and warming above baseline levels by 2050, respectively).**

Especially in the rural contexts in low- and middle-income countries, migration has served as an important strategy to adapt to adverse climate impacts. Climate impacts, both slow- and rapid-onset, adversely affect habitability*** and climate-dependent livelihoods, already changing the patterns of human mobility. In particular, they can accelerate various mobility responses ranging from internal rural-urban migration to temporary involuntary displacement. Overall, climate-related effects on human mobility are diverse and complex. They vary depending on the specific climatic hazards, and the socioeconomic

** Estimate ensemble averages are 170.3 and 78.4 million internal migrants for the “pessimistic” and “climate-friendly” scenarios, respectively.

*** Human habitability can be defined as “the environmental conditions that support healthy human life, productive livelihoods, and sustainable intergenerational development” (Horton, R.M., et al. 2021. Assessing human habitability and migration. *Science*, 372(6548), 1279–1283. doi:10.1126/science.abi8603)

* The term “human mobility” includes different types of movements: within or across borders, permanent, temporary or circular, voluntary or involuntary, as well as the lack of capacity or willingness to move.

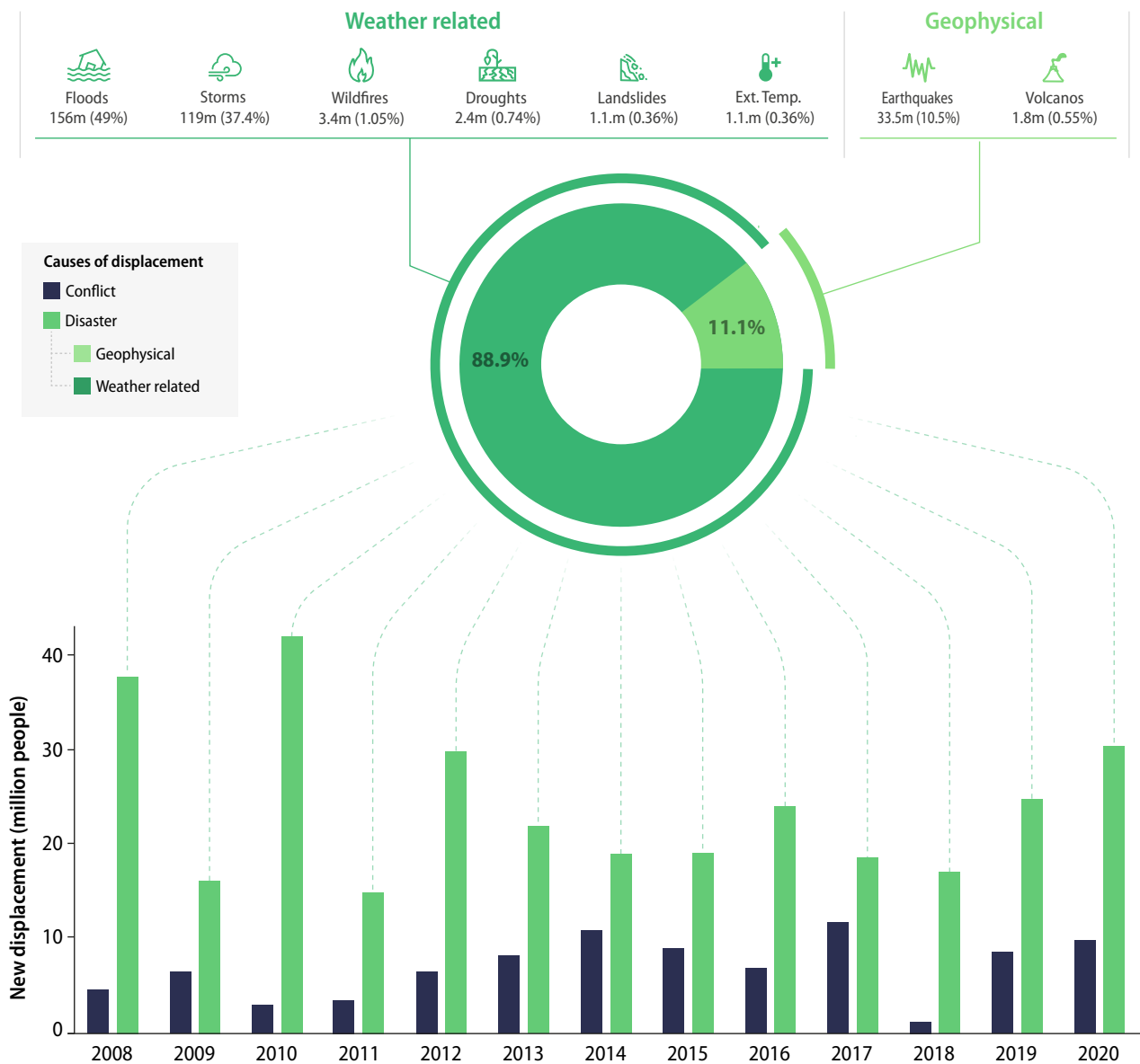


Figure 4. New displacements by disasters breakdown by hazards (accumulated 2008–2020) and compared with displacements by conflict (time-series 2008–2020). Redrawn from IDMC (2021) and Thalheimer et al. (2022).

and political factors shaping vulnerability. A crucial yet often overlooked aspect in the policy arena is that adverse climate impacts can also render socioeconomically vulnerable groups immobile, hindering their ability to adapt. This can happen, for example, as adverse climate impacts diminish people’s resources to engage into migration as an adaptation, which is costly. Particularly affected by involuntary immobility are the poorest regions of the world. This is illustrated by recent multi-country evidence from Cambodia, Nicaragua, Peru, Uganda, Vietnam and Bangladesh showing that low levels of education and income are generally related to a lower likelihood of out-migration after experiencing sudden-onset climate events. Additionally, deciding to remain in place despite the rising climate risks is another potential outcome, as illustrated by case

studies from Chilean Patagonia, as well as Fiji and Tuvalu in the Pacific Ocean.

Human mobility is driven by many factors acting in conjunction. This, together with the limitations in available data, makes it notoriously difficult to attribute individual observed mobility events to climate change. Fortunately, relationships between climate and mobility are becoming clearer thanks to improvements in data availability and research methods, and the resulting accumulated evidence related to the historical effects. But it is important to recognise that quantitative attribution of human mobility patterns to climate change remains elusive. We have a limited – but growing – understanding of the contextual, compounding and cascading climate-mobility links.

IN FOCUS: ANTICIPATORY ACTION

Despite remaining knowledge gaps, it is imperative to advance policy for preparedness. It is essential to shift from a reactive (ex-post response) to an anticipatory approach for humanitarian and development actions, which entail ex-ante, longer-term planning to manage climate-related mobility and immobility. Anticipatory interventions (e.g. forecast-based financing, planned relocation) have already gained prominence in the climate, development and humanitarian communities. For example, during severe winters in Mongolia, forecast-based financing mechanisms have been deployed by the International Federation of Red Cross and Red Crescent Societies, including the distribution of livestock nutrition kits and unconditional cash transfers, to reduce livestock mortality and protect vulnerable pastoralists. In drought-affected Somalia, pilot anticipatory actions by the Food and Agriculture Organization specifically target food insecurity in the light of worsening drought conditions.

Anticipatory action can help prevent or reduce involuntary displacement among vulnerable communities, as well as the loss of ability to migrate as an adaptive strategy. Ahead of extreme weather events, anticipatory actions include strengthening shelters, the early harvesting of crops and evacuation, which in turn facilitate people's return in a timely manner, reducing the likelihood of prolonged displacement. In the context of slow-onset climate change impacts such as sea-level rise, far-sighted planned (voluntary and highly consultative and participatory) relocation of whole communities will increasingly gain importance as an adaptation measure, if adaptation in situ fails. It is worth highlighting the example of Fiji, where planned relocations have been carried out in the past decade and are generally considered successful, thanks to extensive consultation of and participation by the affected communities. Guidelines have been drawn for other states to also benefit from their experience.

IMPLICATIONS AND RECOMMENDATIONS

For climate negotiators and decision makers at all levels – international, national and local:

- Shift from a reactive (ex-post response) to an anticipatory approach, which entails ex-ante longer-term planning and enhancing preparedness to minimise displacement as well as the inability to move driven by climate and weather impacts. Ensure ways to accommodate interests and protect the rights of diverse socioeconomic groups representing gender, age, ethnicity, class etc. when conceiving anticipatory measures.
- It is important to facilitate safe and orderly migration as an adaptive strategy to climatic pressures, including circular migration. However, to ensure that migration serves as an efficient adaptation, it remains crucial to prepare receiving areas ahead of time to absorb the inflow of climate migrants. This includes preparation of labour and housing markets, as well as cultural integration.
- Planned and voluntary relocation of whole communities should only be considered if in situ adaptation strategies fail or are not feasible (Insight 1). Learning from previous cases is crucial to minimise further negative effects for the affected communities. Top-down relocations almost always increase vulnerability. Therefore, highly consultative processes with strong participation from the affected communities are absolutely essential.
- Even in the face of increasing climate risks, some communities might be reluctant to move due to their strong attachment to the place of origin. In such circumstances, authorities should be prepared to co-develop alternative strategies with the affected communities.

5 Human security requires climate security

KEY POINTS

- Human security depends on climate action.
- Climate change does not cause conflict; rather, it exacerbates existing vulnerabilities in human security (caused by governance and socioeconomic conditions), which can lead to violent conflict.
- By increasing vulnerabilities and instability, the human security impacts of climate change become national security concerns.
- Effective and timely mitigation and adaptation strategies are required to strengthen human security and, by extension, national security. These must be pursued in parallel with concerted efforts to provide for human security to reduce the risks of increasing violent conflict and promote peace.
- The Russian invasion of Ukraine has revealed significant problems in terms of food supply and stable access to energy at local, national and international scales that arise from a dependence on fossil fuels. These vulnerabilities erode human security.

INSIGHT EXPLAINED

Human security and climate change interact in insidious “vicious circles” that drive short- and long-term action and impacts. In some contexts, this can exacerbate tensions or amplify existing violent conflicts. A variety of global governance bodies, including the UN Security Council, have recognised that climate and security are linked in complex ways, and that the impacts of this interaction vary widely within and among countries. Ice loss in the Arctic due to climate change, for example, has led to increased international security concerns with countries developing their military capacity there, and availing themselves of expanded maritime transportation channels and natural resource extraction opportunities.

Climate change is inextricably linked with history and societal structures. Its origins, as well as the extent and distribution of impacts on human security, are connected with governance, socioeconomic conditions and human activities, including colonial legacies. Today, the impacts of anthropogenic climate change are undermining fundamental aspects of human security. Access to food, water and energy are threatened, as well as non-material aspects of culture such as traditional knowledge and practices, which are key to successful adaptation and resilience building.

It is a complex picture. The latest IPCC assessment report (AR6) stated that at higher global warming levels, by increasing vulnerability, impacts of

weather and climate extremes – particularly drought – “will increasingly affect violent intra-state conflict”. On the other hand, the overall risk of conflict is projected to decline in the long term in contexts where non-climatic drivers are reduced (such as access to water, food, energy and a sustainable livelihood).

Human insecurity, propelled by resource scarcity and decreased productivity of agricultural lands, can increase tensions within and across communities, in some instances contributing to violent conflict. The UN Environment Programme recently reported that “since the mid-twentieth century, at least 40% of all intrastate conflicts have been linked to the exploitation of natural resources”.

Within these vicious circles, insecurity can also fuel climate change. Scarcity of water or food may lead to additional and predatory exploitation of natural resources for survival or short-term monetary gain. Environmental crimes, such as illegal deforestation, illegal fishing, illegal logging and illegal mining, can increase. These activities precipitate environmental destruction, both directly and indirectly yielding GHG emissions, for instance through land-use changes (see Insight 6).

To prepare better for security threats requires a deeper understanding of how climate factors interact with socioeconomic vulnerabilities. These relationships are magnified when water, energy and/or social systems are severely degraded or decimated by armed conflicts (e.g. from the various chemicals contained in the explosives and the disturbance of radioactive soils), as witnessed, for example, in the recent wars in Ethiopia, Gaza, Sudan, Syria and Yemen, as well as the military invasions of Iraq and Afghanistan. Parties to the conflicts have targeted crops, farms, roads, fishing vessels, irrigation and agricultural infrastructure, and services that are essential to civilian life. The cumulative impact of these incidents over time damages human security, increases vulnerability and limits adaptation to a changing climate.

Action is required across multiple scales to strengthen human security: by local and national policymakers, as well as regional and international institutions. Effective and timely mitigation and adaptation are essential to reduce the contribution of climate change to amplifying the drivers of conflict. Yet, unless mitigation and adaptation efforts are paired with concerted efforts to provide for human security, such action will be insufficient to reduce the risks of increasing violent conflict and promote peace.



Famine in Somalia | Women rush to a feeding centre in Badbado, a camp for Internally Displaced Persons (IPDs). Photograph: UN Photo / Stuart Price (CC BY-NC-SA 2.0)

IN FOCUS: THE RUSSIAN INVASION OF UKRAINE

The recent invasion of Ukraine has demonstrated the reverberating effects of a regional war on global food (wheat, cooking oil) and energy (gas, oil) supply chains. It has also raised the visibility of the use of dams and environmental resources as military tools and targets by state and non-state actors in armed conflicts and other direct impacts of wars. Some countries resorted to ramping up the use of coal to replace natural gas, initiating new fossil fuel extraction projects previously sidelined by climate goals, or increas-

ing subsidies on oil to compensate for surging oil prices. Although a few countries accelerated their renewable energy share, the trend in the first few months of this conflict indicated a regression of decarbonisation efforts. These short-term responses to human security crises caused by violent armed conflict will have deleterious long-term ramifications for climate change, and its detrimental contribution to human security.

IMPLICATIONS AND RECOMMENDATIONS

At a global level:

- Recognition that human security requires climate security further highlights the urgency of effective and timely climate action and a targeted approach to resilience-building.
- The intrinsic relevance of security challenges to meeting climate goals must be incorporated into international climate negotiations (e.g. at COP27), as in, for example, the attention and resources deferred from climate action to address security, or the negative implications of landscapes and farmlands degraded in conflict or on account of human insecurity and additional climate-warming emissions from military action.
- The inverse is also true: an evidence-based approach to international security planning and action (such as through the UN Security Council) would incorporate climate change as integral to their calculations of risk and their approach to the future (including awareness that military resource use, waste and emissions must be reined in significantly in support of climate goals).
- Key powers must be engaged in cross-cutting solutions, rooted in the reality that addressing climate change is essential to reduce the drivers of human insecurity and mitigating its impacts is mutually beneficial.
- Climate change is a catalyst for international cooperation.

At a national and local level:

- Addressing the underlying socioeconomic conditions that can propel communities through “vicious circles” created between conflicts and climate stressors is a vital element of a policy toolbox.
- Recognising that dependence on fossil fuels entails major vulnerabilities, notably for energy security, is an essential early step to developing “win-win” alternatives that are aligned with climate goals.
- The urgent transformation required for the race to net-zero emissions may negatively impact human security in some contexts, making attention to existing injustices, areas of resource scarcity, and vulnerability to climate change even more important to mitigating conflict.

6 Sustainable land use is essential to meeting climate targets

KEY POINTS

Agricultural intensification that is long-term sustainable is preferable to further expansion into natural areas, when proper policies are in place to limit increased land conversion. Efforts to increase food production through enhanced yields and system integration while minimising adverse ecological impacts can likewise do much to further food security.

Land uses that achieve an optimal bundle of services (for climate solutions, food security and ecosystem integrity alike) depend on the climate pathway – the higher the degree of warming, the less likely the current assumptions about the capacity of land systems to deliver these co-benefits will apply.

Integrated land management can provide climate solutions while also benefiting people and the environment; however, land-use changes entail trade-offs more often than mutual wins. Approaches that work to balance trade-offs identified by stakeholders are more likely to provide socially acceptable climate and conservation outcomes

INSIGHT EXPLAINED


A radical shift in land use is required to achieve net-zero carbon emissions by 2050. Agricultural expansion is a major driver of forest loss in the tropics and thus a key driver of GHG emissions, biodiversity loss and the degradation of ecosystem services vital to the livelihoods of nature-dependent and rural people. Land systems* are thus central to two critical COP26 outcomes: the Declaration on Forests and Land Use and the Global Methane Pledge.

Meanwhile, the impacts of climate change (such as from droughts and extreme weather events) on agricultural yields are already affecting land systems, reducing ecological and social resilience

* Defined as terrestrial socioecological systems where human and environmental systems interact through land use (Meyfroidt, P., et al., 2022. Ten facts about land systems for sustainability. PNAS, 119(7). doi:10.1073/pnas.2109217118)

and threatening livelihoods, particularly those of the most vulnerable. Global geopolitical shocks, such as the war in Ukraine, further diminish resilience and serve to demonstrate how globally interdependent agricultural supply chains can increase food system vulnerability, aggravating food insecurity and having important repercussions for landscapes and people across the globe. Important changes to how we use land are needed to avoid undesirable future outcomes. Protecting land systems for the benefit of people and the planet requires an integrated approach to climate change mitigation and adaptation, along with jurisdictional and landscape-scale strategies and approaches.

Climate mitigation through land-use change can support multiple co-benefits. For instance, preventing the conversion of natural forests,

A man in a white shirt is kneeling in a field, tending to rows of maize plants. The field is densely planted with red amaranth, which is used as a cover crop to control weeds and conserve soil moisture. The man is holding a small bundle of red amaranth plants in his hands.

Maize intercropped with red amaranth |
Red amaranth (a leaf vegetable widely used
in Bangladesh) helps to control weeds and
conserve soil moisture. Photograph: D.B.
Pandit/CIMMYT (CC BY-NC-SA 2.0)

protecting existing primary and old growth forests and restoring degraded forests will protect biodiversity, environmental services and livelihoods, while capturing and storing more carbon. However, it is essential to also account for key integrative functions of land for people (e.g. food, nature or cultural benefits, including sense of place) to ensure that land systems are more likely to be just, resilient to shocks, and productive. Moreover, uncertainty about plants' ability to absorb carbon in high-emission futures may further diminish effectiveness of land-based mitigation strategies. Therefore, any climate mitigation scheme must foster ongoing capacity for further adaptation and change by the people and social systems dependent on this land.

Food security can be improved by ensuring reliable water supplies and soil integrity, especially in the face of extreme climate events such as drought. Conservation and regenerative farming practices, such as no-till systems, use of cover crops, and leaving plant residue on the field, can improve soil quality and increase soil organic carbon stocks – the major mitigation strategy from land

use, e.g. the International “4 per 1000” Initiative. Healthy soils have higher water-holding capacities and are less susceptible to erosion, which helps to preserve soil productivity for future generations.

Systematically reducing the climate impact of existing land activities has enormous potential. Examples of positive effects of soil conservation on food security and the environment can be observed across the globe, in both high- and lower-income contexts, as evidenced in recent studies from Zimbabwe, Mozambique and Northeast India. In the United States, improved forest, cropland and rangeland management could provide ~45.8 Gt CO₂e of mitigation by 2100. In Canada, land-use practices related to the conservation, management and restoration of natural systems have an emission reduction potential of 78.2 Tg CO₂e/yr by 2030, equivalent to the emissions of this country's heavy industry in 2018. Best-practice approaches for researchers and policymakers to implement elsewhere would wisely be founded on a synthesis of positive lessons from a variety of diverse contexts.

IN FOCUS: CO-BENEFITS OF CLIMATE-SMART LAND MANAGEMENT

There is compelling evidence that effective management of natural landscapes can yield climate solutions with significant co-benefits to social systems. Though the goal of net zero by 2050 will require significant shifts in business-as-usual, effective policy actions can help provide food, livelihoods, nature and a sense of place and identity, while also providing climate solutions. For instance, managing forests and tree-based ecosystems, grasslands, peatlands and agricultural lands can lead to improved soil productivity, clean air and water, and biodiversity conservation – while simultaneously securing those systems against climate extremes. Though it is also critical to recognise that the functions of land are so diverse and crucial to humanity that land-based carbon sinks should be viewed as a co-benefit of sustainable land management, rather than the other way around.

An effective land-based solution to climate change will prioritise reducing gross emissions from land-based activities. Some carbon sequestration through land systems is also necessary to compensate for hard-to-reduce emissions and achieve net-zero emissions. Urgent policy actions are needed to: (a) prevent the conversion of natural ecosystems, in particular tropical deforestation and degradation; and (b) curb methane and nitrous oxide emissions, in particular from livestock and other agricultural activities. Putting equity considerations at the centre of these land-based climate solutions is essential for their overall moral grounding, but also their effectiveness. Land-system changes that prioritise ecological concerns and ignore equity will likely only be a temporary solution to a very narrow framing of the problem.

IMPLICATIONS AND RECOMMENDATIONS

At a global level, it is suggested that all parties to the UNFCCC:

- Strengthen forest-based actions of the Paris Agreement, to prevent the conversion of natural ecosystems, particularly tropical deforestation and degradation.
- Recognize and account for the abundance of trade-offs involved in pursuing a single goal related to land use (i.e. nature conservation or tree-planting), as they could severely impact other functions of land to people.
- Harmonise different approaches to accounting for emissions from land-use activities to increase transparency and improve monitoring of the progress of Nationally Determined Contributions (NDCs): methodological approaches and definitions of natural and managed areas need to be standardised to reduce the uncertainty about the emissions associated with land-use change, land cover and forests. Going forward, transparent and scientifically robust accounting will be required to broadly include land-use activities in the NDCs. Support for rigorous impact evaluation is urgently needed.

At a national and local level, policymakers must:

- Implement policies and incentives to reduce non-CO₂ gas emissions, such as methane and nitrous oxide, from livestock and other agricultural practices.
- Support the transition of existing agricultural systems towards more sustainable and resilient land management practices, helping to build healthier soils and ensure efficient water use, to engender long-term food security.
- Recognise that the shift towards conservation and regenerative practices takes some time to unfold; targeted governmental support of farmers during the transition period is crucial for incentivising sustainable changes. In many cases, crop yields will improve, but often during the transition period, food production will drop. Governments must be poised to protect those most exposed to shocks, such as those with reduced access to food, during these transitions.
- Support vulnerable groups and regions in adapting land management strategies towards anticipated extremes, such as through diversification, supportive risk management strategies, and provision of alternative livelihoods.
- Seek and promote land management solutions that deliver co-benefits for people and the planet. This will be aided by involving local communities in the design of potential solutions and supporting the development of the democratic and adaptive governance processes that support implementation.

7 Private sustainable finance practices are failing to catalyse deep transitions

KEY POINTS

- Financial markets are crucial for delivering net zero, especially in economic sectors with heavy climate impacts. However, private sector “sustainable finance” practices are not yet catalysing the profound and rapid transformations needed to meet climate targets.
- The large majority of today’s sustainable finance practices are designed to fit into the financial sector’s existing business models rather than to allocate capital in ways that would provide the most impact on combating climate change. The result is that a large share of sustainable finance practices to date do not have strong impacts for shifting capital; they are only moderate drivers of sustainability.
- Implementing and strengthening climate policy measures, such as carbon prices and taxes, minimum standards, and support measures for low-carbon solutions, remain most important for directing economic incentives towards climate solutions and thus shifting capital towards these solutions.
- Private sustainable finance practices must also advance rapidly so that they are better aligned with climate policy efforts and enhance those efforts. To this end, policymakers need to develop policies aimed directly at the financial sector that (a) significantly improve on the transparency of emissions embodied in investments and savings; and (b) ensure that capital flows become aligned with the Paris targets in ways that have real impacts on emissions and resilience in our economies.

INSIGHT EXPLAINED

Societal decarbonisation involves almost all business sectors and requires large investments in new technologies and practices. As a consequence, financial markets are crucial in the transition to net zero, especially for raising the sustainability performance for economic sectors with heavy climate impacts and enabling effective adaptation across the global economy. The financial sector can seem like a giant tanker that takes a long time to change course, but its climate-focused global initiatives are finally helping to shift the direction of business activities. Among them are the Task Force on Climate-related Financial Disclosures, the Network for Greening the Financial System, and the

EU Taxonomy for Sustainable Activities in response to climate change risks. So-called climate finance, green bonds and socially responsible investment (collectively sustainable finance and investment, or SFI) are also all on the rise.

Negotiations surrounding climate finance continue to be contentious, but some progress was made at COP26. The Glasgow Climate Pact provides entry points for public and private financiers to make good on their climate pledges. Further, the private finance sector has launched initiatives such as the Glasgow Financial Alliance for Net Zero, which manages US\$130 trillion of assets, the Net-Zero Insurance Alliance, and the Green Finance Platform. The

number of signatories by investment companies to the Principles for Responsible Investment rose from 63 in 2006 to 1,715 in 2018. This signified a change in assets held from US\$6.5 trillion to US\$81.7 trillion. Climate finance is also growing, averaging US\$632 billion in 2019–2020, as is sustainable debt, which stood at US\$1.6 trillion in 2021.

But climate finance needs to move faster. Recent research shows that private sector sustainable finance practices are not influencing the real economy to the point that could catalyse the deep and rapid transformations needed to meet the climate targets, and in some cases can encourage environmentally damaging practices that erode resilience for humans and the planet. There is a lack of evidence for sustainable practice claims made by sustainable firms who fail to clarify the real impact on people and ecosystems. In a similar vein, it has been found that there are limited sustainability outcomes of SFI in the context of the European Union. It has been noted that it complements but cannot replace strong policy measures such as carbon prices and taxes and regulatory standards.

Reforms in the governance of climate metrics and disclosure are needed to ensure that claims of capital allocation to climate-friendly investments lead to low-carbon development and climate resilience in real economies. One solution, widely endorsed by finance scientists and professionals, is to develop decision-support tools such as metrics, rankings, ratings and standards. There should also be a monitoring mechanism to ensure that these

standards are being followed. However, issues such as inconsistencies in international standards and in governmental involvement in green bonds need to be resolved, probably through harmonisation, to overcome the differences between markets, in the practices of governments and institutions, and in environmental focus areas including carbon and ecosystems.

One promising area is the potential for global financial services and capital markets to drive climate action via sustainable finance. There is a strong positive correlation between active engagement by the “Big Three” investor companies (BlackRock, Vanguard and State Street Global Advisors) and reduced emissions of the chief emitters. Institutional investors can improve environmental, social and governance (ESG) performance via engagement with the companies they have ownership stakes in.

Looking ahead, various green financial standards might be enacted by combining different models that can be tailored to local circumstances. The task could be achieved through the efforts of governments and intermediary actors, together with progressive financial institutions. To be sure, stronger public action and policies will be crucial to facilitating the shift in private capital needed to achieve the climate targets. Such means could include direct public financing, public risk mitigation and national regulating (including of the financial sector itself), as well as carbon taxes and pricing.

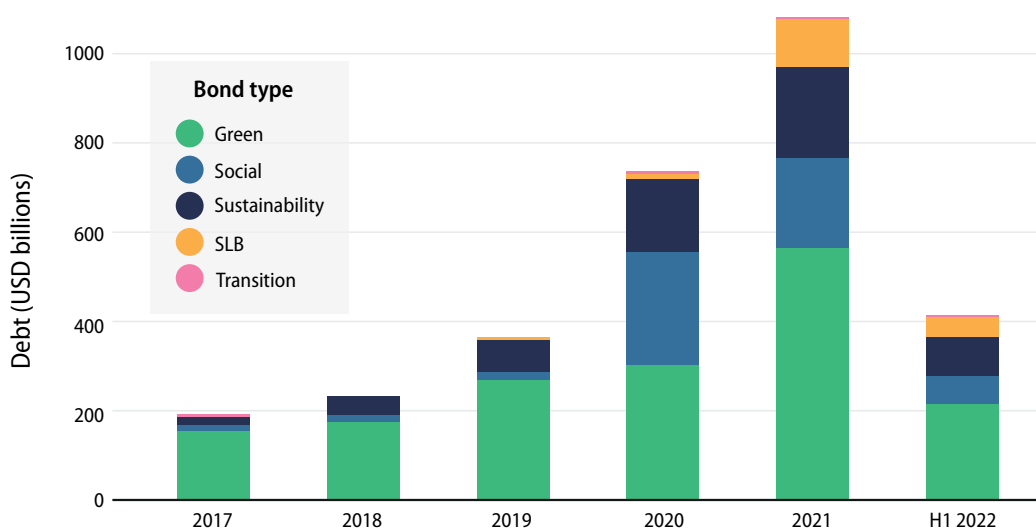


Figure 5. Sustainable Finance annual issuance and market outlook. This graph includes green, social, sustainability, sustainability-linked bonds (SLB), and transition-labelled debt. Cumulative total labelled issuance stood at US\$3.3 trillion at the end of H1 2022. Redrawn from Sustainable Debt Market Summary H1 2022 (August 2022), Climate Bonds Initiative (<https://www.climatebonds.net/market/data/>).

IN FOCUS: THE FINANCIAL SECTOR MUST SHAKE OFF ENDEMIC GREENWASHING

The financial sector is in an early stage of reckoning where it faces the multifaceted challenges related to climate change. The key constraints to demonstrating the material addition of sustainable finance include the data-related gaps in climate disclosure and metrics as well as inadequate analytical tools such as ESG ratings. These are obstacles to the orderly transition to low-carbon economies, as evidenced by the financial sector's lateness in recognising corporate greenwashing and the related risks for effective sustainable finance practices. One

study found no difference in the environmental performance of ESG and non-ESG mutual fund companies, only differences in the level of voluntary ESG disclosure. In essence, sustainable finance is hobbled by the greenwashing practices endemic in sustainability reports. Consequently, the financial sector needs to build capacity towards assessing and managing the flaws evident in sustainable investment practices so that tangible sustainability-improving outcomes are prioritised.

IMPLICATIONS AND RECOMMENDATIONS

Most sustainable finance practices do not deviate from existing expectations on profit in the financial sector. In addition, the global finance system currently suffers from critical constraints, such as data gaps in climate disclosure and metrics as well as inadequate analytical tools that limit the finance sector's ability to effectively align the allocation of capital with climate targets.

Climate negotiators and decision makers at all levels – international, national and local – need to:

- Develop strong policies requiring high levels of transparency and accuracy in the reporting of the emissions associated with investments, savings and economic activity, especially in the banking sector and in capital markets given the direct link between credit and economic activity.
- Facilitate financial sector transparency: decision makers must develop or strengthen policies and tools that ensure that those companies and the sectors responsible for the largest share of emissions are accurately reporting their emissions throughout their value chains and not engaging in greenwashing.
- Develop policies aimed directly at the financial sector that ensure that capital flows become aligned with the Paris climate targets, with a particular emphasis on the real economy impacts of this alignment.
- Adopt broader climate policies that ensure that climate-friendly investments are economically viable and that emissions-intensive activities become increasingly economically unviable, thus creating incentive structures that strongly incentivise financial actors to direct capital towards climate solutions.

The finance sector needs to:

- Develop and implement improved and more-transparent methods to assess the climate impacts of the capital they manage and the climate-related risks and opportunities they face in the transition to net-zero by the mid-century.
- Develop clear strategies with both short-term and long-term targets/milestones for how they will align their capital allocation with the targets of the Paris Agreement.
- Ensure that the sustainable finance practices adopted to allocate capital to climate-friendly investment actually lead to low-carbon development and climate resilience in the real economy.

8 Loss and Damage: the urgent planetary imperative

KEY POINTS

- Losses and damages are already happening and will increase significantly on current trajectories, but rapid mitigation and effective adaptation can still prevent many of these.
- While many losses and damages can be calculated in monetary terms, there are also non-economic losses and damages that need to be better understood and accounted for.
- A coordinated, global policy response to losses and damages (known by the capitalised Loss and Damage) is urgently needed.

INSIGHT EXPLAINED

Cutting GHGs and adapting to climate realities can only take us so far. The harms caused by climate change impacts that are difficult or impossible to avoid through mitigation and adaptation are known as losses and damages (I&d). Communities everywhere are beginning to experience I&d to their livelihoods and ancestral lands, including vulnerable communities in nations that bear minimal historical responsibility for climate change – placing this issue at the heart of climate justice.

Losses and damages from climate change are not just a future risk, but are already a present reality as a result of slow-onset climatic changes and extreme weather events that can increasingly be attributed to anthropogenic climate change. For example, low-lying coastal areas face existential risks from flooding, while heat-stressed places face more life-threatening heatwaves as the magnitude of climate change impacts in these places exceeds what can be adapted to (see Insight 1). Current trends are expected to cause I&d to increase significantly, including for example in the lowest-lying island nations, which are at risk of becoming uninhabitable. The IPCC's 6th Assessment Report states with high

confidence that “with increasing global warming, losses and damages will increase and additional human and natural systems will reach adaptation limits” (IPCC AR6 WGII, SPM, 2022).

The policy response to I&d – known as (upper case) Loss and Damage (L&D) – is gaining traction, but it is yet to emerge as distinct from adaptation, whether at the national or international level. Meanwhile, political disagreements around the role of historical responsibility and compensation have slowed progress on L&D policy at the UNFCCC level. Climate financing for L&D remains a major barrier in the negotiations. Insurance plays a role in addressing I&d in cases that have not been (or could not be) avoided by adaptation, but it is no help to people who have suffered I&d that cannot be monetised (see the In focus box, below). Innovative international legal mechanisms, including potentially climate litigation, will be necessary to protect impacted individuals' rights, as well as to, for example, guard nations' exclusive economic zones in the sea that are drawn relative to land territory (which may be lost).

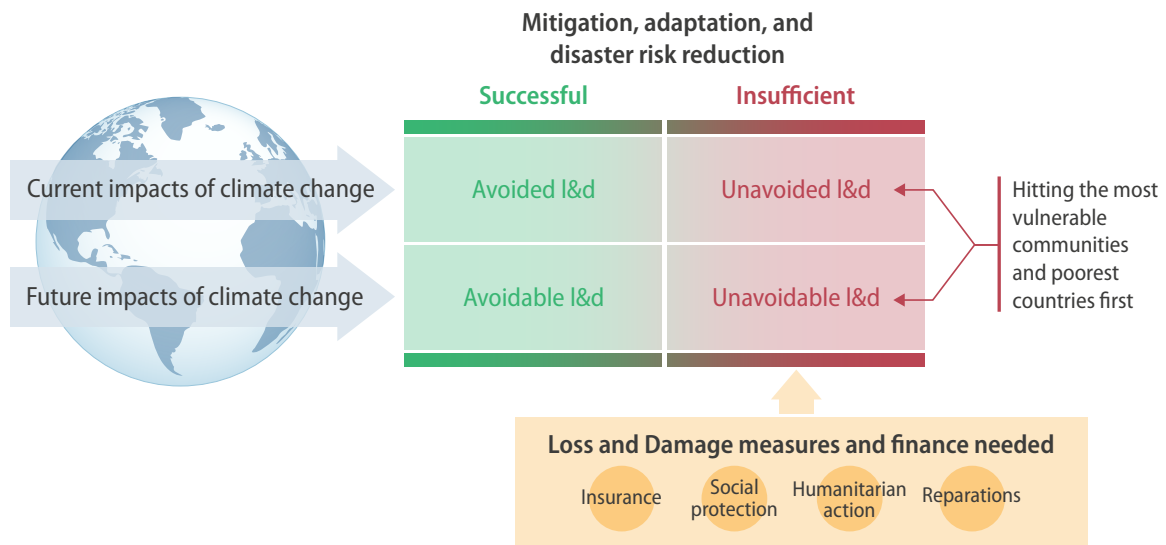


Figure 6. Mitigation, Adaptation, and Loss and Damage: Current impacts of climate change can be prevented from turning into losses and damages through adaptation, while future impacts can be avoided by adaptation and mitigation. But when this is insufficient, Loss and Damage measures and finance are needed to ameliorate the losses and damages borne largely by the most vulnerable.

IN FOCUS: THE BROADENING DEFINITIONS OF LOSS AND DAMAGE

Losses and damages (I&d) can manifest in many different ways, and current approaches to “avert, minimise and address” them span four broad strategies: risk reduction, risk transfer, risk retention and transformational approaches. The upper case Loss and Damage (L&D) refers to the political and policy response to addressing I&d but lacks a consensus definition, with at least four distinct perspectives observed: adaptation and mitigation, risk management, limits to adaptation and existential.

Not all I&d are reducible to economic terms; rather we also need to consider, for example, life, health, mobility, territory, identity, agency, sense of place, social cohesion, cultural heritage, Indigenous knowledge, biodiversity and ecosystem services. These non-economic losses and damages (NELD) are already being experienced in communities. Failing to consider NELD distorts understandings of climate change impacts (e.g. loss of cultural rituals due to failed harvests), discounts peoples’ experiences (e.g. destruction of sacred places or cemeteries), and skews future decision-making (e.g. towards capital and away from capabilities).

IMPLICATIONS AND RECOMMENDATIONS

Climate negotiators and decision makers at all levels – international, national and local – need to:

- Improve the accuracy of calculations of ongoing and future I&d. This is crucial, among other things, so that I&d can be included in global stocktaking.
- Treat L&D as a distinct policy area, notwithstanding that there are clear overlaps with adaptation.
- Broaden understandings and definitions for NELD.
- Seek innovative legal and financial mechanisms to protect individuals’ and nations’ rights in response to I&d.

9 Inclusive decision-making for climate-resilient development

KEY POINTS

- Climate-resilient development is built on societal choices that go beyond the formal decision-making of politicians and policymakers.
- Being inclusive and empowering in all forms of decision-making has been shown to lead to better and more just climate outcomes.
- Currently, the sort of "inclusive" decision-making being done is insufficient to meet the needs of either climate action or justice.

INSIGHT EXPLAINED

Choices affecting the future of the globe's climate are being made all around us. Decisions are taken every day in town halls and voting booths, corporate boardrooms, government offices, private homes, community meetings and on the streets. However, not everyone's voice is equitably represented, and we can no longer afford to pretend otherwise. Pervasive injustices in decision-making – highlighted in recent research – perpetuate exclusionary practices across sectors and contexts in both mitigation and adaptation. These dynamics amplify unequal outcomes. Climate risks become increasingly unevenly distributed, historical injustices become more entrenched, mitigation strategies are deployed that exacerbate rather than ameliorate unequal impacts, and the vulnerabilities of disadvantaged communities and groups are compounded.

Inclusive and empowering governance is therefore critical to enabling climate-resilient development. It was identified as a foundational concept in the IPCC's 6th Assessment Report (IPCC AR6 WGII, 2022), which highlights the importance of mitigation and adaptation actions that advance sustainable development from local to global levels.

Yet, despite the manifold benefits, inclusive and enabling climate change decision-making and action are still rare. This is revealed by, for example, the continued exclusion of Indigenous and traditional knowledge and a lack of intergenerational inclusiveness.

Many may point out that inclusion and participation in public decision-making is already a common-place policy provision. But in reality, procedural inclusion is typically no more than a technocratic checklist exercise demanded by funders or regulators that usually consists of "counting people in" with little consideration of who, how, why and to what effect different voices are accounted for, or of relinquishing any power by those with this privilege to those who should be included. Such processes can actually restrict opportunities for meaningful involvement, since they entrench socioeconomic inequalities, exclusion and political and ecological injustices, while also imposing a false narrative of uniform voice, knowledge and ability to access decision-making opportunities, even suggesting that consensus is always possible. Moreover, inclusion alone does not ensure that divergent worldviews, ideologies, values, interests and needs necessarily inform societal choices about climate change.



Women from Abushouk camp for internally displaced persons on the outskirts of El-Fasher, North Darfur, during a vivid a discussion during the Africa Human Rights Day. Photo: UNAMID (CC BY-NC-ND 2.0)

Transformative change towards inclusive and empowering climate decision-making is needed – in both formal and informal institutional settings – that reflects the cumulative and emergent decisions by individuals, communities and society. Consequently, this would enable a better understanding of divergent views, needs and experiences of climate change and would help prevent generalised, one-size-fits-all solutions. For example, lands managed using Indigenous-led conservation methods have been shown to significantly reduce deforestation, though not always. These processes will look different depending on the scale, geography and culture, but coordination that spans the globe is critical.

Concepts of ‘decentred’ decision-making need to be at the core of emerging policy discussions around GHG mitigation, maladaptation, climate action trade-offs, relocation and limits to adaptation, among others. Decentring can help carve new opportunities for realising climate-resilient development, while being mindful of historical

decisions and actions, such as colonisation and contemporary inequitable and unjust geopolitics, policies and practices. But all these efforts need to be rapidly and dramatically scaled up in the face of observed climate impacts and projected climate risks. Too many inclusive measures are either too far from the wider public sphere or insufficiently entwined with formal decision-making processes and other more established initiatives to have much impact.

In bringing about the required changes, the strategic and operational implications for all actors should not be underestimated – especially those for governments but also for the private sector and civil society, Indigenous peoples, media and scientific institutions, from the local to global levels across both adaptation and mitigation domains. Inclusive and empowering societal choices for climate-resilient development confront prevailing unsustainable practices and the underlying dominant ideologies and structures, and the powerful interests that drive them.

IN FOCUS: ECO-VILLAGES – A MODEL FOR INCLUSIVE AND EMPOWERING GOVERNANCE

Novel approaches to climate resilience are being explored and tested. Eco-villages, being community-led initiatives of an alternative form of living based on local knowledge, sustainability values, circular economy, social empowerment and political participation, are one example. These are, so far, of small scale, but have the potential to increase participation in local politics, and to foster partnerships between society and government. Utopian experiments such as eco-villages promote the interconnect-edness of life, and experiment with collaborative, direct democratic and horizontal forms of organisation and decision-making processes. Eco-villages and other integrative and community-led initiatives can help decentre historical foci of power. They may also “open up” knowledge by making opportunities, spaces or arenas of engagement inclusive and empowering Indigenous peoples, vulnerable communities, youth, marginalised ethnic/racial groups, gender/sexual minorities, migrants and displaced peoples.

IMPLICATIONS AND RECOMMENDATIONS

At a global level, it is suggested that all parties to the UNFCCC:

- Establish decentred decision-making processes for climate action that genuinely transfer power to those with less, and incorporate divergent worldviews, ideologies, values, interests and needs.
- Coordinate the granular, multi-scalar and decentred decision-making processes both for learnings of effective processes and achievement of broader climate-resilient development.

At the national and local level, policymakers must:

- Pursue climate-resilient development through inclusive and empowering climate decision-making and action of all types.
- Support the development, assessment and scaling up of novel approaches through community-led initiatives.

10 Breaking down structural barriers and unsustainable lock-ins

KEY POINTS

- Mitigation strategies still remain insufficient to limit temperature increase to below 2°C.
- Social progress measured by gross domestic product (GDP) growth and affluence is among the major drivers of GHG emissions, ingraining a resource-intensive economy that is a significant barrier to climate change mitigation.
- Vested interests within this political and economic system entrench unsustainable lock-ins – such as behavioural norms geared towards status consumption, business models focused on ever-increasing production, weak or vague climate policies, and even the use of outright violence that benefits fossil fuel industries – across social norms, industry and economy.
- Costs of climate change driven by a fossil fuel-based energy system are readily externalised onto communities deprived of the collective agency to resist.
- Interventions across all structural barriers simultaneously to remove unsustainable lock-ins are crucial if we are to achieve true transformational change.

INSIGHT EXPLAINED

Despite headline-grabbing climate pledges, only 18 countries have so far shown sustained reductions in production- and consumption-based GHG emissions for longer than 10 years. The gap is widening between national pledges on GHG emissions and the reductions required by the Paris Agreement. As this “emission gap” grows, the urgency to scale and accelerate mitigation is increasing. A big problem, however, is that multidimensional structural barriers arising from the current resource-intensive economy and its vested interests in maintaining the status quo are inhibiting change. As a result, global actions and policies trail far behind targets, setting us on a current trajectory of 2.7°C or higher.

At the heart of the issue is the prevailing narrative of how social progress is defined. Despite rhetoric around sustainable transformations or green

transitions, GHG emissions are driven upwards by ever-increasing production and consumption. Success is still measured predominantly by GDP and affluence, rather than through improvements in resource use efficiency and advancing human wellbeing within the biosphere’s constraints. This resulting resource-intensive economy operates through complex structures of power and production and constitutes a significant barrier to climate change mitigation. These power structures serve vested interests and they entrench unsustainable lock-ins in policy, industry, infrastructure, business models and sociocultural norms that act as multidimensional barriers to climate change action. This happens, for example, through commitments to open-ended GDP growth, brand-building strategies, lobbying and even outright violence that benefits extractive sectors, including the fossil fuel industry.

These commitments and actions prevent a range of climate actions such as financial incentives to reduce emissions and evolve market- and price-based instruments (for example, carbon emission pricing with distributive justice). They prevent collective political will and encourage the maintenance of the status quo in policies and behaviours (see the In focus box, below) resulting in inaction or vague net-zero policies. Delaying effective mitigation through these ambiguous policies or weak strategies is creating a significant over-reliance on practices such as carbon dioxide removal (CDR). Although they play an integral role in achieving 2°C, high-potential CDR measures still face implementation constraints. Delaying mitigation now will further escalate CDR’s uncertainties and will also exceed their hypothetical capacity, making the targets impossible or increasingly difficult to achieve. Not surprisingly, the latest report by the REN21 network shows that fossil fuels still dominate total global final energy consumption, with only negligible changes over the past 10 years: 80.7% in 2009 to 79.6% in 2019 and 78.5% in 2020. The costs of the fossil fuel value chain and climate change are also readily externalised onto communities that do not have the collective agency to resist. This further enables unsustainability in production and consumption decisions and vice versa.

One way to remove the structural barriers and deep-rooted inequalities discussed is to develop a multidimensional indicator of progress of human wellbeing for all. This can help to establish a more progressive economy that delivers new sustainable lock-ins across policy, industry, infrastructure, business models and sociocultural norms. For this to become a reality, there will need to be bottom-up social movements, an increase in low-carbon investments and a continuous de-risking of these investments. It also requires governance that accounts for rebound effects of new technologies (see the In focus box, below), and the improvement of technical and institutional capacity to build policy support for low-carbon development. Taken as a whole, these recommendations can give rise to alternative institutions and new science-driven paradigms. Consequently, development pathways will shift so that production–consumption systems and investment choices are radically transformed – boosting mitigation in both the supply and demand sides. According to the IPCC’s 6th Assessment Report (IPCC AR6 WGII, 2022), end-use sector-focused changes can reduce GHG emissions by 40–70% by 2050, compared with baseline scenarios.

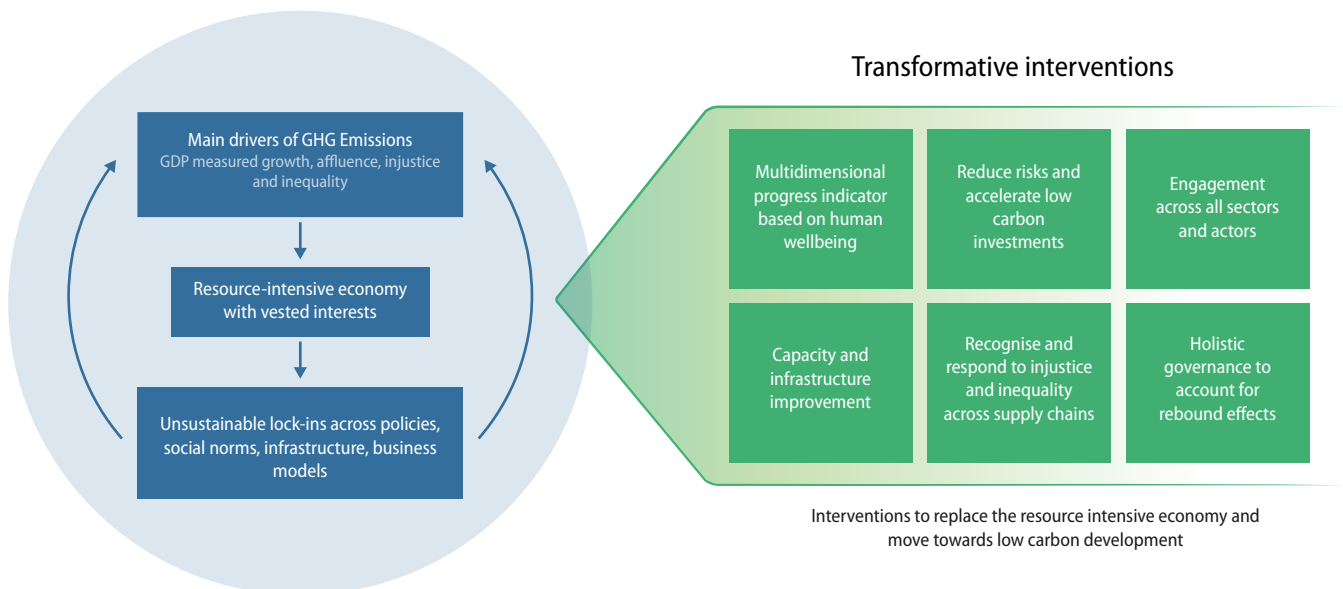


Figure 7. Interconnected and reinforcing resource-intensive economy with vested interests in maintaining GHG emissions and obstructing climate change mitigation (in blue). Transformative interventions (in green) to remove the main drivers of this system are vital in order to replace its unsustainable lock-ins and enable a shift towards low carbon development.

IN FOCUS: DON'T OVERLOOK THE UNSUSTAINABLE LOCK-INS AND REBOUNDS

It is essential to address these carbon emissions already “locked-in” to resource-intensive infrastructures – from big industrial projects down to individual consumer behaviours. If not, there is a danger that new products and services to reduce consumer footprint can lead to unsustainable rebound effects. For example, digital tools are being leveraged by many to increase efficiencies in industry and services and accelerate the development of more sustainable products. However, emission reductions from these efficiency improvements and greener products and services may be offset by increased consumption, leading to a “rebound” and yet more energy use and resource extraction. Resource-intensive lock-ins are interconnected and reinforced through doubt-inducing media strategies that deflect responsibility of climate change mitigation to individuals and disapprove new low-carbon behaviours.

IMPLICATIONS AND RECOMMENDATIONS

Climate negotiators and decision makers at all levels – international, national and local – need to:

- Contextualise and implement multidimensional indicators of human wellbeing to track progress, instead of using traditional and short-sighted metrics of progress such as GDP.
- Create and effectively implement administrative and legal mechanisms to acknowledge and redress the inequality and injustice that exacerbate unsustainability in production and consumption decisions. For example, trade agreements that reflect an understanding of and contribute to redressing environmental injustices across global supply chains.
- Advocate for more progressive production–consumption arrangements and policies that deliver new sustainable lock-ins across industry, infrastructure, business models and sociocultural norms.
- Remove barriers to and de-risk decarbonisation investments.
- Promote governance that accounts for rebound effects due to more-efficient technologies, and the improvement of technical and institutional capacity to build policy support for low-carbon development.



Acknowledgements

The making of this report has been led by Future Earth, The Earth League and the World Climate Research Programme (WCRP).

We acknowledge the work of the following individuals in their respective capacities:

EDITORIAL BOARD

Wendy Broadgate – Future Earth Secretariat, Sweden
Mercedes Bustamante – University of Brasilia, Brazil
Helen Cleugh – Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia
Sabine Fuss – Mercator Research Institute on Global Commons and Climate Change (MCC), Germany
Huang-Hsiung Hsu – National Taiwan University, Taiwan
Saleemul Huq – International Centre for Climate Change and Development (ICCCAD), Bangladesh
Shuaib Lwasa – Global Center on Adaptation, The Netherlands
Cheikh Mbow – Centre De Suivi Écologique, Senegal; University of Pretoria, South Africa
Aditi Mukherji – International Water Management Institute, India
Chukwumerije Okereke – Alex Ekwueme Federal University, Nigeria
Friederike Otto – Imperial College London, United Kingdom
Johan Rockström – Potsdam Institute for Climate Impact Research (PIK), Germany; University of Potsdam, Germany
Lisa F. Schipper – University of Oxford, United Kingdom; University of Bonn, Germany
Peter Schlosser – Global Futures Laboratory, Arizona State University, United States
Detlef Stammer – University of Hamburg, Germany
Rowan Sutton – University of Reading, United Kingdom

EDITOR-COORDINATORS

Clea Edwards – Global Futures Laboratory, Arizona State University, United States
Daniel Ospina – Future Earth Secretariat, Sweden

CHAPTER AUTHORS

INSIGHT 1

Edward R. Carr – Clark University, United States
Tabea K. Lissner – Climate Analytics, Germany
Jaroslav Mysiak – Euro-Mediterranean Center on Climate Change (CMCC), Italy; Ca' Foscari University of Venice, Italy
Chandni Singh – Indian Institute for Human Settlements, India
Maarten van Aalst – Red Cross Red Crescent Climate Centre, The Netherlands; University of Twente, The Netherlands
writer-coordinator:
Gaby S. Langendijk – Climate Service Center Germany (GERICS), Helmholtz-Zentrum Hereon, Germany

INSIGHT 2

Marina Hirota – Federal University of Santa Catarina, Brazil; University of Campinas, Brazil
Ola Johannessen – Nansen Scientific Society, Norway
Anjal Prakash – Indian School of Business, India
Norman J. Steinert – NORCE Norwegian Research Centre, Norway
writer-coordinator:
Sophie Hebden – Future Earth Secretariat, Sweden

INSIGHT 3

Kristie L. Ebi – University of Washington, United States
Meghnath Dhimal – Nepal Health Research Council, Nepal

Catherine Machalaba – oneHEALTH project; EcoHealth Alliance, United States

Virginia Murray – UK Health Security Agency, United Kingdom

writer-coordinator:

Giles B. Sioen – Future Earth Secretariat, Japan; National Institute for Environmental Studies, Japan

INSIGHT 4

Kanta K. Rigaud – World Bank, United States

Barbora Šedová – Potsdam Institute for Climate Impact Research (PIK), Germany

Tasneem Siddiqui – University of Dhaka, Bangladesh

Lisa Thalheimer – Princeton University, United States

writer-coordinator:

Daniel Ospina – Future Earth Secretariat, Sweden

INSIGHT 5

Marwa Daoudy – Georgetown University, United States

Yasuko Kameyama – National Institute for Environmental Studies, Japan

Juan Pulhin – University of the Philippines Los Baños, Philippines

writer-coordinator:

Clea Edwards – Global Futures Laboratory, Arizona State University, United States

INSIGHT 6

Emmanuel A. Boakye – Université du Québec à Montréal, Canada

Ariane de Bremond – Global Land Programme; University of Bern, Switzerland; University of Maryland, United States

Martin Girardin – Laurentian Forestry Centre, Canadian Forest Service, Canada

Luana Schwarz – Potsdam Institute for Climate Impact Research (PIK), Germany

writer-coordinator:

Clea Edwards – Global Futures Laboratory, Arizona State University, United States

INSIGHT 7

Aaron Maltais – Stockholm Environment Institute (SEI), Sweden

Kim Schumacher – Kyushu University, Japan

Jerry Zhirong Zhao – Zhejiang University, China

writer-coordinator:

Sunhee Suk – Future Earth Secretariat, Japan; Nagasaki University, Japan

INSIGHT 8

Emily Boyd – Lund University, Sweden

Karen McNamara – The University of Queensland, Australia

Emmanuel Raju – University of Copenhagen, Denmark; North-West University, South Africa

Murray Scown – Utrecht University, The Netherlands; Lund University, Sweden

Chandni Singh – Indian Institute for Human Settlements, India

Kees van der Geest – United Nations University, Germany

writer-coordinator:

Aaron Redman – Arizona State University, United States

INSIGHT 9

Eric Chu – University of California, Davis, United States

Szilvia Csevár – The Hague University of Applied Sciences, The Netherlands

Bruce Glavovic – Massey University, New Zealand

Karin Ingold – University Bern, Switzerland; Swiss Federal Institute of Aquatic Science & Technology, Switzerland

writer-coordinator:

Aaron Redman – Arizona State University, United States

INSIGHT 10:

Josep Canadell – Global Carbon Project; Commonwealth Scientific and Industrial Research Organisation (CSIRO), Australia

Manu V. Mathai – Azim Premji University, India

Joyashree Roy – Asian Institute of Technology, Thailand; Jadavpur University, India

Karsten Schulz – University of Groningen, The Netherlands

writer-coordinator:

Nilushi Kumarasinghe – Future Earth Secretariat, Canada

We also acknowledge the helpful comments and suggestions on specific Insights provided by Helen Adams, Maurie Cohen, Cedric De Coning, Carol Farbokto, Rachael D. Garrett, Maïke Hamann, Paul Hudson, Fumiko Kasuga, Maria Martin, Daniel Müller, Darla Munroe, Sofía Nanni, David Obura, Juan C. Rocha, Masachika Suzuki, and Monika Zurek.

CUSTODIAN ORGANIZATIONS



SPONSORS



SPONSORS





10 | NEW INSIGHTS IN
CLIMATE SCIENCE

10insightsclimate.science