The Hague Centre
for Strategic Studies

Intersecting Futures

Global Trends Shaping and Shaped by Climate Change over the Next Century

Thijs van Aken and Laura Birkman

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1. Introduction

The risks of climate change are well known. Rising seas, extreme weather, higher temperatures, and natural resource scarcity are driving ecosystem degradation, biodiversity loss, and economic pressures. These direct, or first-order, effects are worsening. States around the world are already facing increased disaster risks, such as the deadly flash flood seen in Texas in July 2025 or the unprecedented 70 day heatwave that struck China's Yangtze River Valley in 2022, affecting more than 900 million people. Extreme weather events and environmental changes also impact economic sectors and livelihoods. Over the last three decades, for example, climate impacts alone have negatively impacted agricultural efficiency with 7.4% in Indonesia, 2.8% in China and 2.5% in Western Europe. Under a high-emission scenario without adaption, these losses could rise to a 36.6% decline of staple crop yields by the end of the century.[1]

Indirect, or second-order, effects are on the rise too, impacting human wellbeing, societal stability, and global relations. The World Health Organization, for example, estimates that climate change could cause around 250,000 additional deaths annually between 2030 and 2050 due to undernutrition, malaria, diarrhoea, and heat stress.[2] Additionally, conflicts related to scarce water resources more than doubled between 2021 and 2023,[3] concentrating in Western and sub-Saharan Africa, Southern Asia and Latin America. According to EU's current climate chief, Wopke Hoekstra, access to such resources has long played a role in conflict and warfare, but the intensifying effects of climate change are expected to multiply this effect significantly, potentially by a factor of four. Maintaining the flexibility to adapt to climate change, is essential.[4]

To address these diverse impacts of climate change now and in the future, states and international organisations around the world are devising climate adaptation strategies. In 2021, for example, the EU presented its renewed commitment to increase climate change preparedness and resilience by 2050. It aims to accelerate adaptation through knowledge generation, data enhancement and by promoting nature-based solutions for adaptation.[5] Building on this strategy, the European Commission aims to establish a new integrated framework for European climate resilience and risk management in the second half of 2026.[6] Other countries that have developed a National Adaptation Plan or are in the process of doing so

1 Andrew Hultgren et al., 'Impacts of Climate Change on Global Agriculture Accounting for Adaptation', Nature 642, no. 8068 (2025): 650, https://doi.org/10.1038/s41586-025-09085-w.

2 World Health Organisation, 'Climate Change and Health', 12 October 2023, https://www.who.int/news-room/fact-sheets/detail/climate-change-and-health.

3 Pacific Institute, Fact Sheet: Water Conflict Chronology Update (Pacific Institute, n.d.), https://pacinst.org/wp-content/uploads/2024/08/Water-Conflict-Chronology_Fact-Sheet.pdf.

4 Alice Hancock, 'Hotter World Will Drive More Wars, EU Climate Chief Warns', Climate Change, Financial Times, 5 June 2025, https://www.ft.com/content/a1d0e1d1-104c-4fc1-ae12-1ffb508eab42.

5 European Commission, 'EU Adaptation Strategy', European Commission, 24 February 2021, https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2021:82:FIN.

6 ropean Commission, 'European Climate Resilience and Risk Management – Integrated Framework - Climate Action', European Commission, accessed 31 March 2026, https://climate.ec.europa.eu/eu-action/adaptation-and-resilience-climate-change/european-climate-resilience-and-risk-management-integrated-framework_en.

include China, India, and 75 other countries across the Global South.[7] International efforts are also being made to address the unevenly distributed impacts of climate change in nations that lack the capacity to respond. The United Nations Environment Programme, for example, has supported climate adaptation initiatives in more than 50 countries, primarily in the Global South.[8]

These efforts are not enough, however, as developing countries still face a financing gap of at least $284 billion annually to adequately adapt to the adverse effects of climate change.[9] While significant amounts of funding are needed to enable worldwide climate adaption, the costs of inaction are equally daunting. Under a scenario of 3°C global warming, average global GDP losses are projected to reach 10%, with some regions in the Global South facing losses of more than 15%.[10] Even in a conservative scenario of 1.5°C, climate impacts are projected by the World Meteorological Organization to reach $1.266 trillion over the period 2025-2100.[11]

Climate change is more than an environmental issue: it acts as a threat multiplier across social, economic and political systems.

As more states emphasise the need for climate adaptation, it is important to understand the short- and long-term dynamics that shape climate adaptation efforts. This essay explores how climate change will intersect with major global trends between 2025 to 2100. These trends – including geopolitical shifts, population growth, economic transformations, technological advancements, and broader societal changes – will increasingly interact with climate impacts. As such, climate change is more than an environmental issue: it acts as a threat multiplier across social, economic and political systems. Instead of progressing in a linear way, these developments will occur in waves, as each climate-related disruption sets off a chain of shocks across regions and sectors.

In the short to medium term, inadequate responses to climate change will lead to an increase in frequency and severity of climate-related events and disasters. Affected societies will face growing instability as a result of political inaction, disinformation, and psychological strain. Climate change will also create new geopolitical flashpoints, especially in the Arctic, where melting ice caps will open new sea routes and increase inter-state competition over valuable resources, such as natural gas, oil, and rare earth minerals.[12] Access to climate-critical materials and technologies will become increasingly vital for adapting to climate change, prompting global powers to pursue energy security and strategic gains.

By mid-century, climate impacts will further intensify, but so will the capacity to respond. The OECD projects that global exposure to drought will increase four-fold by 2050, with droughts

7 National Climate Change Adaptation Strategy 2035 (Peoples Republic of China, 2022), http://www.ncsc.org.cn/SY/syqhbh/202206/W020221026516413083356.pdf; UNDP Climate Change Adaptation, 'Building Climate Resilience in India by Initiating the National Adaptation Plan Process and Scaling up Adaptation Finance I', UNDP Climate Change Adaptation, September 2024, https://www.adaptation-undp.org/projects/building-climate-resilience-india-initiating-national-adaptation-plan-process-and-scaling; UN Climate Change, 'Submitted NAPs from Developing Country Parties', accessed 31 March 2026, https://napcentral.org/submitted-naps.

8 UNEP & Climate Adaptation: What We Do (United Nations Environmental Programme, 2023), https://wedocs.unep.org/bitstream/handle/20.500.11822/40977/climate_adaptation.pdf?sequence=3&isAllowed=y.

9 United Nations Environment Programme, Adaptation Gap Report 2025: Running on Empty - The World Is Gearing up for Climate Resilience — without the Money to Get There (2025), 50, https://doi.org/10.59117/20.500.11822/48798.

10 Paul Waidelich et al., 'Climate Damage Projections beyond Annual Temperature', Nature Climate Change 14, no. 6 (2024): 594–95, https://doi.org/10.1038/s41558-024-01990-8.

11 World Meteorological Organization, State of the Global Climate 2023 (World Meteorological Organization, 2024), 30, https://library.wmo.int/records/item/68835-state-of-the-global-climate-2023.

12 Kenneth J. Bird et al., 'Circum-Arctic Resource Appraisal: Estimates of Undiscovered Oil and Gas North of the Arctic Circle', in Fact Sheet, nos 2008–3049 (U.S. Geological Survey, 2008), https://doi.org/10.3133/fs20083049.

lasting twice as long by 2100. Under a high-emissions scenario, climate-induced internal migration in South Asia, Latin America, and Africa will more than double, rising from about 50 million to 118 million people.[13] These pressures will strain international relations but may also drive innovation, spurring advancements in technologies like vertical farming and AI-powered climate adaptation. This can help governments and societies manage disruptions more effectively, while economies that embrace these shifts and diversify through green innovation are likely to prove more resilient.

In the second half of this century, climate-related developments will contribute to profound global transformations. Power dynamics are likely to shift, favouring those countries that can adapt swiftly and sustainably. Meanwhile, ecological tipping points, such as disrupted water cycles, melting permafrost, changing ocean currents, and biodiversity loss, could trigger irreversible and cascading consequences for the planet.

Overall, climate change will be a defining force shaping global developments throughout the course of the 21st century. This essay examines the geopolitical, geoeconomic, technological, environmental, and societal trends that will interact with climate change and explores the opportunities and challenges this will present for nations, economies, and societies.

Climate change will be a defining force shaping global developments throughout the course of the 21st century.

13 Groundswell Part 2: Acting on Internal Climate Migration, 13 September 2021, 7, https://hdl.handle.net/10986/36248.

2. Geopolitical Shifts and Pressures

Global governance of climate adaptation and mitigation is evolving within an increasingly fragmented and transactional international order. As the world moves towards multipolarity, regional dynamics and pragmatic coalitions of countries will shape future bilateral and multilateral cooperation on climate adaptation. In this context, climate adaptation is becoming a strategic dimension in international relations, one that can serve as both a unifying factor as well as a potential source of tension between countries. States most vulnerable to climate impacts will intensify demands for international financing and equitable access to climate-critical technologies and adaptation measures. Consequently, control over such technologies and measures is emerging as a strategic asset central to geopolitical competition and international relations. As new coalitions and agendas arise, historical tensions between the Global North and South – rooted in historical emissions and divergent adaptive capacities – will remain a divide in global climate action. At the same time, China and India present themselves as potential drivers of climate adaptation and leaders for the broader Global South.

Countries' ability to adapt to climate change will prove a determining factor for the global balance of power.

By the end of the century, those states that are able and willing to adapt to the impacts of climate change will be well-positioned to gain geopolitical influence, form new coalitions, and shape global and regional climate adaptation agendas. Particularly states in sub-Saharan Africa, the Middle-East and North Africa (MENA), and South Asia may unlock significant economic growth as the Global North faces demographic and economic stagnation. Countries unable to adapt effectively, however, risk increased social fragility and authoritarianism, fuelling broader regional and global instability.

This chapter elaborates on the geopolitical shifts and pressures that are likely to reshape the global governance of climate change over the next 25 years and beyond. Illustrating how by the end of the century, countries' ability to adapt to climate change will prove a determining factor for the global balance of power.

2.1. Climate Geopolitics in a Fragmenting World (now-2050)

Fragmentation and multipolarity result in block-forming and transactionalism. The decline of the post-Cold War international order challenges the current global governance of climate change. In the coming decades, the international system will continue transitioning from unipolarity, dominated by the United States, to a system of multipolarity in which a variety of great powers project their influence and interests on the international stage.[14] Global institutions governing global climate action are losing their relevance, as emerging powers question

[14] Michael A. Peters, 'The Emerging Multipolar World Order: A Preliminary Analysis', Educational Philosophy and Theory 55, no. 14 (2023): 1653–63, https://doi.org/10.1080/00131857.2022.2151896; Tobias Bunde et al., Munich Security Report 2025: Multipolarization (Munich Security Conference, 2025), https://doi.org/10.47342/ezuc8623.

the legitimacy and equity of existing international regimes and norms.[15] Instead, regional dynamics will shape multilateral cooperation, that will be increasingly centred around pragmatic coalitions of countries with specific shared interests.[16] In this context, the role of minilateralism and coalitions of the willing are likely to become increasingly important complements of multilateralism, enabling faster implementation and more targeted cooperation on climate and biodiversity where broader negotiations stall.[17]

Increasingly pressing impacts of climate change can also present themselves as a unifying factor between competing states and new regional coalitions.

In this fragmenting international order, however, the increasingly pressing impacts of climate change can also present themselves as a unifying factor between competing states and new regional coalitions.[18] While the Trump administration has further retreated from the US's leadership role in global climate governance, the EU remains formally committed to a robust climate agenda.[19] At the same time, the EU's political priorities are increasingly shaped by concerns about competitiveness, industrial strategy and resilience.[20] Meanwhile, China and India present themselves as important actors in global climate politics and potential drivers of climate mitigation and adaptation in the broader Global South.[21] Through its South-South Climate Cooperation Program, for example, China has stimulated cooperative climate action by funding over 100 climate mitigation and adaptation projects in developing countries across Africa and Asia.[22] India's recent free trade agreement with the EU, as part of the broader EU-India Comprehensive Strategic Agenda, illustrates the growing interlinkages between climate policy, trade and industrial development.[23] Initiatives such as the G7-backed Just Energy Partnerships and Africa-EU green energy cooperation illustrate this shift to smaller, purpose-driven coalitions. Thus, while block-forming and transactionalism challenge the global governance of climate change, opportunities arise to forge new coalitions and regional agendas to tackle its impacts.[24]

15 Andrew Hurrell and Sandeep Sengupta, 'Emerging Powers, North—South Relations and Global Climate Politics', International Affairs (Royal Institute of International Affairs 1944-) 88, no. 3 (2012): 463–84; Gregorio Bettiza and David Lewis, 'Authoritarian Powers and Norm Contestation in the Liberal International Order: Theorizing the Power Politics of Ideas and Identity', Journal of Global Security Studies 5, no. 4 (2020): 559–77, https://doi.org/10.1093/jogss/ogz075.

16 Frank Bekkers et al., De Strategische Monitor 2023 | Barsten En Blokken: Confrontatie En Samenwerking in Een Wereld van Wisselende Coalities (HCSS, n.d.), 8, accessed 14 May 2025, https://hcss.nl/report/de-strategische-monitor-2023-barsten-en-blokken/.

17 Robert Falkner, 'A Minilateral Solution for Global Climate Change? On Bargaining Efficiency, Club Benefits and International Legitimacy', GRI Working Papers, GRI Working Papers, July 2015, 197, https://ideas.repec.org//p/lsg/lsgwps/wp197.html.

18 Alexander Thompson, 'From Rivals to Partners: The Cooptation of Emerging Powers into the Climate Regime', Contemporary Security Policy 46 (2025): 126–49, https://doi.org/10.1080/13523260.2024.2420477.

19 Chico Harlan, 'Trump Just Reversed Course on Two Key U.S. Climate Pledges', The Washington Post, 8 March 2025, https://www.washingtonpost.com/climate-environment/2025/03/08/trump-climate-finance-funds/; Nina Lakhani and Nina Lakhani Climate justice reporter, 'US Exits Fund That Compensates Poorer Countries for Global Heating', US News, The Guardian, 7 March 2025, https://www.theguardian.com/us-news/2025/mar/07/us-exits-fund-that-compensates-poorer-countries-for-global-heating; 'Global Climate Action', European Commission, 2025, https://climate.ec.europa.eu/eu-action/international-action-climate-change/global-climate-action_en.

20 Thomas de Waal, 'Taking the Pulse: Has Europe Given Up Its Leadership on Climate Change?', Carnegie Endowment for International Peace, 6 November 2025, https://carnegieendowment.org/europe/strategic-europe/2025/11/taking-the-pulse-has-europe-given-up-its-leadership-on-climate-change.

21 Karoliina Hurri, 'The Roles They Play: Change in China's Climate Leadership Role during the Post-Paris Era', Globalizations 20, no. 7 (2023): 1065–82, https://doi.org/10.1080/14747731.2023.2186107; Kamya Choudhary, 'How Is India Tackling Climate Change?', Grantham Research Institute on Climate Change and the Environment, 2022, https://www.lse.ac.uk/granthaminstitute/explainers/how-is-india-tackling-climate-change/.

22 Jianfeng Jeffrey Qi and Peter Dauvergne, 'China's Rising Influence on Climate Governance: Forging a Path for the Global South', Global Environmental Change 73 (March 2022): 6, https://doi.org/10.1016/j.gloenvcha.2022.102484.

23 'Towards 2030: A Joint European Union-India Comprehensive Strategic Agenda', Text, European Commission, 27 January 2026, https://ec.europa.eu/commission/presscorner/detail/en/statement_26_224; Colette van der Ven, 'The EU-India FTA: A New Model Linking Trade, Climate and Industrial Policy?', Borderlex - European trade policy, Borderlex - European Trade Policy, 30 January 2026, https://borderlex.net/2026/01/30/the-eu-india-fta-a-new-model-linking-trade-climate-and-industrial-policy/.

24 Nataliya Stranadko, 'Global Climate Governance: Rising Trend of Translateral Cooperation', International Environmental Agreements: Politics, Law and Economics 22, no. 4 (2022): 654–55, https://doi.org/10.1007/s10784-022-09575-6.

The rise of climate geopolitics introduces a new geopolitical dynamic centred on countries' vulnerability to climate change and their capacity to adapt to it. The number of states highly vulnerable to climate change has steadily increased in recent years and is expected to continue doing so. Regions across Africa, South Asia, South America, and the Small Island Developing States (SIDS) are particularly exposed to escalating risks, including extreme weather events, food and water insecurity, and large-scale displacement.[25] As the impacts of climate change unfold, adaptation needs in developing countries alone are estimated to represent annual investments of approximately $310-365 billion/year up to 2035.[26] While the need for climate adaptation is rising, countries' ability to implement adaptation measures is moderated by their adaptive capacity. This capacity is shaped by access to financial and technological resources, socio-economic resilience, stability of governance structures and quality of knowledge systems.[27]

In an increasingly transactional international order, control over such technologies and measures is likely to become a strategic asset central to geopolitical competition and international cooperation.

In this context, climate adaptation is poised to become an increasingly strategic factor in shaping bilateral relations and international cooperation. On the one hand, countries facing existential climate threats, especially those with limited adaptive capacity, are expected to intensify calls for stronger climate adaptation efforts.[28] This trend is exemplified by the Alliance of Small Island Developing States, which despite their limited weight in global politics has formed a leading voice in climate change adaptation agenda-setting over the past decades.[29] At the same time, a growing number of states will pursue access to climate-critical technologies and adaptation measures. In an increasingly transactional international order, control over such technologies and measures is likely to become a strategic asset central to geopolitical competition and international cooperation.[30]

Climate financing is subject to a global divide between the Global North and South. While developed states have contributed the majority of historical greenhouse gas emissions, developing countries are disproportionately at risk of climate change impacts and have limited capacity to adapt to them.[31] In recent climate negotiations, developing countries have increasingly called attention to this unequal burden sharing, arguing that historical emitters should contribute to mitigation and adaptation efforts in the Global South.[32] Although this has prompted several initiatives including the Loss and Damage Fund,[33] acquiring sufficient

25 Nikolas Scherer and Dennis Tänzler, The Vulnerable Twenty – From Climate Risks to Adaptation (Climate Diplomacy, n.d.), 46–48; Hans-Otto Pörtner et al., eds, 'Summary for Policymakers', in Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (Cambridge University Press, 2022), 17.

26 Programme, Adaptation Gap Report 2025.

27 Kimberley Thomas et al., 'Explaining Differential Vulnerability to Climate Change: A Social Science Review', WIREs Climate Change 10, no. 2 (2019): e565, https://doi.org/10.1002/wcc.565.

28 Robbert Biesbroek et al., 'Policy Attention to Climate Change Impacts, Adaptation and Vulnerability: A Global Assessment of National Communications (1994–2019)', Climate Policy 22, no. 1 (2022): 107, https://doi.org/10.1080/14693062.2021.2018986.

29 Adelle Thomas et al., 'Climate Change and Small Island Developing States', Annual Review of Environment and Resources 45, no. Volume 45, 2020 (2020): 16–18, https://doi.org/10.1146/annurev-environ-012320-083355.

30 Scott Moore, Climate Action in the Age of Great Power Rivalry: What Geopolitics Means for the Climate (Kleinman Center for Energy Policy, 2024), 3–4, https://kleinmanenergy.upenn.edu/research/publications/climate-action-in-the-age-of-great-power-rivalry-what-geopolitics-means-for-the-climate/.

31 M. W. Jones et al., 'National Contributions to Climate Change Due to Historical Emissions of Carbon Dioxide, Methane, and Nitrous Oxide since 1850', Scientific Data 10, no. 155 (2023), https://doi.org/10.1038/s41597-023-02041-1.

32 'How Deep Is the North-South Divide on Climate Negotiations?', Carnegie Endowment for International Peace, 6 October 2021, https://carnegieendowment.org/research/2021/10/how-deep-is-the-north-south-divide-on-climate-negotiations?lang=en.

33 'COP28 Agrees to Establish Loss and Damage Fund for Vulnerable Countries', World Economic Forum, 1 December 2023, https://www.weforum.org/stories/2023/12/cop28-loss-and-damage-fund-climate-change/.

funding for climate adaptation remains challenging. While developing countries are in need of $310-365 billion climate adaptation financing annually, international public adaptation finance commitments amounted to only $26 billion in 2023.[34] If recent declines in global foreign aid budgets persist, closing this financing gap will become increasingly unlikely in the coming decades.[35] Minilateral financing arrangements may help to address implementation gaps, but without transparency, fairness, and local ownership they risk reinforcing inequalities and further eroding trust. Additionally, as the world becomes more fragmented and multipolar, donor countries will be increasingly driven by national security and geoeconomic interests. Consequently, opportunities for climate adaptation funding may become more dependent on blended finance, public-private partnerships, and other non-traditional instruments, alongside traditional aid and concessional public finance, over the coming decades.[36]

2.2. **Demographic Shifts and Emerging Risks to Global Stability (2050-2100)**

Donor countries will be increasingly driven by national security and geoeconomic interests.

Demographic and economic shifts result in a rebalancing of the international order, reshaping the geopolitical landscape of climate change governance. While the Global North has dominated the governance of climate change over the past decades, its influence is set to decline as it is challenged by ageing populations and economic stagnation. According to UN projections, most European states have already reached or will reach their peak population in the next 30 years, followed by a decline of 14-20% throughout 2054-2100. At the same time, the percentage of people aged 65 and above in these regions is expected to reach 23-33% by 2054, rising to 40% in 2100.[37] The accompanying decline in the working-age population will reduce annual GDP per capita growth by 0.4%, with a projected negative impact of $10.000 in GDP per capita by 2050.[38] Contrastingly, populations in sub-Saharan Africa are expected to more than double to 3.3 billion people by the end of the century. This demographic growth and still youthful population present an opportunity to realise substantial economic growth over the coming decades.[39] Similarly, populations South Asia, including India, house significant economic potential.[40]

If sub-Saharan and South Asian states are able to realise their economic potential in the second half of this century – which is dependent on substantial investments in education, health care and infrastructure – they are positioned to gain significant geopolitical influence.[41]

34 Programme, Adaptation Gap Report 2025.

35 'International Aid Falls in 2024 for First Time in Six Years, Says OECD', OECD, 16 April 2025, https://www.oecd.org/en/about/news/press-releases/2025/04/official-development-assistance-2024-figures.html.

36 'Foreign Aid in Decline amid New Geopolitics', GIS, 9 May 2025, https://www.gisreportsonline.com/r/foreign-aid-decline/.

37 World Population Prospects 2024: Summary of Results (United Nations, 2024), 16–31, https://desapublications.un.org/publications/world-population-prospects-2024-summary-results.

38 Anu Madgavkar et al., Dependency and Depopulation? Confronting the Consequences of a New Demographic Reality (McKinsey Global Institute, 2025), 31, https://www.mckinsey.com/mgi/our-research/dependency-and-depopulation-confronting-the-consequences-of-a-new-demographic-reality; Ronald Lee and Andrew Mason, 'Cost of Aging', Finance & Development 54, no. 1 (2017), https://www.imf.org/external/pubs/ft/fandd/2017/03/lee.htm.

39 World Population Prospects 2024, 36–44.

40 Ayla Majid, 'Regional Collaboration Could Unlock South Asia's Economic Potential', World Economic Forum, 19 May 2025, https://www.weforum.org/stories/2025/05/unlocking-south-asia-economic-potential/.

41 Signé Landry et al., 'Leveraging Africa's Inner Strength to Realize Its Full Economic Potential', Brookings, 13 January 2025, https://www.brookings.edu/articles/leveraging-africas-inner-strength-to-realize-its-full-economic-potential/; Aparna Pande, 'India Is on the Rise', GIS, 20 November 2023, https://www.gisreportsonline.com/r/india-rise/.

Meanwhile, if countries in the MENA, particularly the Gulf States, succeed in economic diversification, they might also enhance their strategic influence on the global energy transition and climate resilience agenda.[42] This emerging shift in the global balance of power offers opportunities for African, Middle Eastern, and South Asian states to form new coalitions and shape global and regional climate adaptation agendas.[43]

Insufficient climate action increases the risk of global instability, particularly in contexts with limited adaptive capacity. States that fail to adapt to rising sea levels, extreme weather events, heat, and drought will face cascading environmental and social impacts that could result in societal fragility.[44] Internal displacement, resource scarcity, and economic shifts will strain already fragile government structures, risking their collapse and opening the possibility for conflict both within and between states.[45]

Failure of democracies to take meaningful climate action undermines their legitimacy.

Three pathways are identified that amplify risks for societal fragility and global instability. First, flood- and drought-prone regions will experience destabilising effects from internal displacement and resource scarcity.[46] For example, in a worst-case scenario up to 5 billion people could be faced with desertification and uninhabitable lands by 2100.[47] Second, the failure of democracies to take meaningful climate action undermines their legitimacy, increasing authoritarian sentiments among populations experiencing climate stress.[48] Increased authoritarianism will amplify the fragmentation of the current world order, reinforcing its unstable and transactional character.[49] Third, fossil fuel-producing states are expected to face major societal and political challenges if they fail to decarbonise their fossil fuel-dependent economies.[50] Political elites will have to resort to new sources of economic rent to maintain political legitimacy and social stability.[51]

42 Aisha Al-Sarihi, 'Energy Transition in the Gulf: Best Practices and Limitations', Carnegie Endowment for International Peace, 17 April 2025, https://carnegieendowment.org/research/2025/04/energy-transition-in-the-gulf-best-practices-and-limitations.

43 Thor Olav Iversen et al., 'Trailblazers in a Warming World? The Agency of African Actors in Climate, Peace, and Security', African Security 17, nos 3–4 (2024): 251–76, https://doi.org/10.1080/19392206.2024.2433889; Choudhary, 'How Is India Tackling Climate Change?'

44 Luke Kemp et al., 'Climate Endgame: Exploring Catastrophic Climate Change Scenarios', Proceedings of the National Academy of Sciences 119, no. 34 (2022): e2108146119, https://doi.org/10.1073/pnas.2108146119.

45 Xiaolan Xie et al., 'The Impacts of Climate Change on Violent Conflict Risk: A Review of Causal Pathways', Environmental Research Communications 6, no. 11 (2024): 112002, https://doi.org/10.1088/2515-7620/ad8a21.

46 Michalis I. Vousdoukas et al., 'Small Island Developing States under Threat by Rising Seas Even in a 1.5 °C Warming World', Nature Sustainability 6 (2023): 1552–64, https://doi.org/10.1038/s41893-023-01230-5; 'Three-Quarters of Earth's Land Became Permanently Drier in Last Three Decades: UN', UNCCD, 21 September 2024, https://www.unccd.int/news-stories/press-releases/three-quarters-earths-land-became-permanently-drier-last-three-decades.

47 Enrique Morán-Tejeda and Jonathan Spinoni, The Global Threat of Drying Lands: Regional and Global Aridity Trends and Future Projections (2024), 14, https://www.unccd.int/sites/default/files/2024-12/aridity_report.pdf?utm.

48 Nomi Claire Lazar and Jeremy Wallace, 'Resisting the Authoritarian Temptation', Journal of Democracy 36, no. 1 (2025): 135, 136, 139.

49 Sajjad Hussain and Azhar Ahmad, 'THE RISE OF AUTHORITARIANISM IN THE 21st CENTURY AND THE WORLD ORDER', Journal of Contemporary Studies 9, no. 1 (2020): 1, https://doi.org/10.54690/jcs.v9i1.24.

50 Sarah Pech and Sarah Chayes, The Oil Curse (Carnegie Endowment for International Peace., 2015), 7–17, https://carnegie-production-assets.s3.amazonaws.com/static/files/CP_250_Peck_Chayes_Oil_Curse_Final.pdf.

51 Aditya Sarkar and Alex de Waal, 'Going "Cold Turkey": Oil Addiction and "Traumatic" Decarbonization in Fragile Fossil Fuel Producers', Environment and Security 2, no. 3 (2024): 335–39.

3. Geoeconomic and Technological Trends

Meeting the existential demands of global climate adaptation and mitigation in the second half of this century will require fundamental economic transformation.

While shifting geopolitical dynamics reshape global governance, technological innovations, resource competition, and extreme weather events define the geoeconomic dimension of climate adaptation. Over the coming decades, technological advancements are set to offer significant economic opportunities and solutions for climate adaptation. At the same time, these innovations carry second-order environmental risks and may foster techno-solutionism that undermines more robust climate adaptation strategies. As technology becomes central to successful climate adaptation, states will seek control over critical raw materials and green technology supply chains. Meanwhile, extreme weather events increasingly threaten these supply chains, critical infrastructures, and food security. Financial systems, on their part, face the challenge of adapting to these increasing climate risks to enable the massive private investments required for global climate adaptation.

Meeting the existential demands of global climate adaptation and mitigation in the second half of this century will require fundamental economic transformation. Climate-resilient economies will emerge in those countries that are able to mobilise financial investments, innovation and public support for climate policy. However, as the fiscal means for climate investments remain concentrated in established economies, regional imbalances and inequalities between the Global North and South may persist. By 2050, these disparities may increasingly unfold not just between regions but also within them, as uneven climate exposure, fiscal constraints and technological access generate differentiated adaptation pathways. Recent analysis of the situation in the EU already suggests that uneven exposure to climate stress can strain solidarity and governance. If these patterns persist, similar inter-regional fractures could become more pronounced in the second half of the century. Unequal access to fifth industrial wave technologies and climate impacts on agriculture will amplify these inequalities but also offer new avenues for global cooperation on climate adaptation.

Over the coming decades and century, these technological and economic trends will play a critical role in enabling global climate adaptation. This chapter explores both the opportunities for innovation-driven climate adaptation these trends offer and the risks they pose of deepening global inequalities.

3.1. Critical Dependencies: Innovation, Supply Chains and Financing (now-2050)

Technological advancements are positioned to provide innovate solutions for climate adaptation, with estimates for adaptation market size ranging from an $55 billion by 2032 to $140 billion by 2034.[52] AI-driven climate models, for example, are expected to provide greater efficiency and precision in environmental monitoring and foresight.[53] Specifically, multimodal AI models can improve the accuracy and lead time of early warning systems for extreme weather events, floods, and droughts, enabling faster disaster response and more effective adaptation measures.[54] Additionally, AI applications may be used to support improvements in adaptation and sustainability across sectors such as energy, industry, waste management, and agriculture.[55] Despite serious reservations, countries faced with severe climate impacts may pursue technological applications involving the physical, biological and chemical manipulation of global and local environments, or so-called geoengineering.[56] Solar geoengineering, for example, is argued to offer temporary temperature relief by manipulating the atmosphere or clouds to increase reflection of incoming solar radiation, reducing immediate climate change impacts.[57]

The application of these technologies is not without risks, however. Environmentally, the development and use of AI involves large-scale energy and resource consumption, waste, and consequentially large-scale carbon footprints.[58] Additionally, AI models remain prone to biases in training data and lack of transparency in analyses.[59] Geoengineering, on its part, remains largely untested in the real world and is expected to cause significant unintended side effects, such as reducing global rainfall, exacerbating ocean acidification, and harming the ozone layer.[60] All technological innovations carry the risk of techno-solutionism: a false sense

52 ltd, 'Climate Adaptation Market Size to Hit USD 55.44 Billion by 2032, at a CAGR of 9.46%', SNS Insider, 28 February 2025, https://www.globenewswire.com/news-release/2025/02/28/3034826/0/en/Climate-Adaptation-Market-Size-to-Hit-USD-55-44-Billion-by-2032-at-a-CAGR-of-9-46-Research-by-SNS-Insider.html; Fortune Business Insights, Climate Adaptation Market Size, Share & Growth Analysis, By Solution (Technology-Based Solution and Early Warning and Monitoring Climate Solution), By End-User (Public Sector, Research Institutes, and Industries), and Regional Forecast, 2026-2034 (2026), https://www.fortunebusinessinsights.com/climate-adaptation-market-111804.

53 Rana Afreen Shaikh et al., 'AI FOR CLIMATE CHANGE: ENHANCING PREDICTIVE MODELS FOR CLIMATE PATTERNS AND AI-DRIVEN ENVIRONMENTAL MONITORING', Journal of Emerging Technologies and Innovative Research 11, no. 10 (2024): 517.

54 Markus Reichstein et al., 'Early Warning of Complex Climate Risk with Integrated Artificial Intelligence', Nature Communications 16, no. 1 (2025): 2564, https://doi.org/10.1038/s41467-025-57640-w.

55 Jeanette Jackson, 'The Tech Paradox: Climate Change vs. Digital Innovation', Foresight Canada, 4 July 2023, https://foresightcac.com/article/the-tech-paradox-climate-change-vs-digital-innovation?utm_medium=Social&utm_source=Facebook; Harshita Jain et al., 'AI-Enabled Strategies for Climate Change Adaptation: Protecting Communities, Infrastructure, and Businesses from the Impacts of Climate Change', Computational Urban Science 3 (July 2023): 12, https://doi.org/10.1007/s43762-023-00100-2; 'Leveraging Innovative Technologies for Climate Resilience', Climate Change IEEE, accessed 1 May 2025, https://climate-change.ieee.org/news/technological-innovation-for-climate-change/.

56 Zhihua Zhang et al., 'Review of Geoengineering Approaches to Mitigating Climate Change', Journal of Cleaner Production, Carbon Emissions Reduction: Policies, Technologies, Monitoring, Assessment and Modeling, vol. 103 (September 2015): 899, https://doi.org/10.1016/j.jclepro.2014.09.076.

57 Jesse L. Reynolds and Joshua B. Horton, 'An Earth System Governance Perspective on Solar Geoengineering', Earth System Governance 3 (March 2020): 100043, https://doi.org/10.1016/j.esg.2020.100043.

58 Rahib Imamguluyev, 'Artificial Intelligence 2050: Predictions, Challenges, and Innovations', International Journal of Research Publication and Review 5, no. 9 (2024): 2936, https://doi.org/10.55248/gengpi.5.0924.2663.

59 Jain et al., 'AI-Enabled Strategies for Climate Change Adaptation', 13.

60 Sam Adelman, 'Geoengineering: Rights, Risks and Ethics', Journal of Human Rights and the Environment 8, no. 1 (2017): 119–21.

of security based on the expected success of technological innovations, which can hinder the development of more robust long-term climate adaptation strategies.[61]

Access to critical raw materials (CRMs) and green technologies is becoming a determining factor in the success of national climate adaptation and mitigation strategies. Global demand for CRMs used in green technologies is projected to triple by 2040 as countries implement their energy and climate commitments.[62] By 2040, the combined market value of these materials could reach $770 billion, with value chains concentrated in a limited number of countries hosting mining and refinement operations.[63] Production of green technologies such as electric vehicles, batteries and carbon capture equipment is highly concentrated too, with China, Japan, South Korea, the EU and the US exporting the most low-carbon technology compared to their total exports.[64] Notable is China's central role in global CRM supply chains for green technologies, as it currently possesses 75% of the global production capacity for lithium-ion batteries and produces 94% of the global supply of permanent magnets used in wind turbines and electric vehicles.[65] Additionally, China is projected to maintain control of more than half of the world's CRM refinement capacity by 2040, housing more than 75% of global refinement capacity for rare earths, cobalt and graphite.[66]

The highly concentrated nature of CRM supply chains for green technologies is driving two geoeconomic trends: first, resource nationalism, and second, the strategic use of trade dependencies.

The highly concentrated nature of CRM supply chains for green technologies is driving two geoeconomic trends: first, resource nationalism, and second, the strategic use of trade dependencies.[67] The rising demand for CRMs and green technology coincides with heightened concerns over national interests and security risks, driving states to increase protection and control of natural resources to ensure the security of supply in times of crises.[68] Countries already in control of critical supply chains can increasingly leverage their dominance for economic and political gains in international politics.[69] The fivefold increase of export restrictions on CRMs between 2009 and 2023 exemplifies this trend, rising from 2,518 to roughly 17,500.[70] While the drive for strategic autonomy on CRMs will result in a fragmentation of international trade, it can also give rise to new resource-based partnerships.[71]

61 The European Institute for International Relations, 'Can Technological Innovations Solve the Climate Crisis?', The European Institute for International Relations, 14 March 2025, https://www.eiir.eu/recent-topics/can-technological-innovations-solve-the-climate-crisis/.

62 'Critical Minerals', IEA, 2025, https://www.iea.org/topics/critical-minerals.

63 Global Critical Minerals Outlook 2024 (International Energy Agency, 2024), 96–101, https://www.iea.org/reports/global-critical-minerals-outlook-2024.

64 Jing Shuai et al., 'Renewable Energy Product Competitiveness: Evidence from the United States, China and India', Energy 249 (2022): 123614, https://doi.org/10.1016/j.energy.2022.123614.

65 IEA, 'Lithium-Ion Battery Manufacturing Capacity, 2022-2030', IEA, 2023, https://www.iea.org/data-and-statistics/charts/lithium-ion-battery-manufacturing-capacity-2022-2030; Vasileios Rizos et al., 'Developing a Supply Chain for Recycled Rare Earth Permanent Magnets in the EU', 2022, 14, https://circulareconomy.europa.eu/platform/sites/default/files/2023-01/Developing%20a%20supply%20chain%20for%20recycled%20rare%20earth%20permanent%20magnets%20in%20the%20EU.pdf.

66 Global Critical Minerals Outlook 2024, 101.

67 Sharon E. Burke et al., Critical Minerals - Global Supply Chains and Indo-Pacific Geopolitics, NBR Special Report no. 102 (The National Bureau of Asian Research, 2022), 2, https://www.nbr.org/wp-content/uploads/pdfs/publications/sr102_criticalminerals_dec2022.pdf; Bogdan Stojanovic, 'The Geopolitics of Critical Raw Materials: Who Controls the Future?', Diplo, 13 February 2025, 13, https://www.diplomacy.edu/blog/the-geopolitics-of-critical-raw-materials-who-controls-the-future/.

68 Sekarsari Sugihartono, 'The Current Trend of De-Globalization: Protectionism and Resource Nationalism', Modern Diplomacy, 20 September 2024, https://moderndiplomacy.eu/2024/09/20/the-current-trend-of-de-globalization-protectionism-and-resource-nationalism/.

69 Burke et al., Critical Minerals - Global Supply Chains and Indo-Pacific Geopolitics, 2.

70 OECD, Raw Materials Critical for the Green Transition (OECD, 2023), https://www.oecd.org/en/publications/raw-materials-critical-for-the-green-transition_c6bb598b-en.html; OECD, 'OECD Inventory of Export Restrictions on Industrial Raw Materials 2025: Monitoring the Use of Export Restrictions Amid Growing Market and Policy Tensions', OECD Publishing, 12 May 2025, https://doi.org/10.1787/facc714b-en.

71 Gita Gopinath, IMF, 2024, https://www.imf.org/en/News/Articles/2024/05/07/sp-geopolitics-impact-global-trade-and-dollar-gita-gopinath; Vlado Vivoda, 'Friend-Shoring and Critical Minerals: Exploring the Role of the Minerals Security Partnership', Energy Research & Social Science 100 (June 2023): 103085, https://doi.org/10.1016/j.erss.2023.103085.

Extreme weather events are making global supply chains and corridors more volatile and unreliable, resulting in harmful impacts on transport efficiency and increased financial losses in large-scale freight transport.

Extreme weather events are becoming increasingly frequent and disruptive for critical infrastructures and supply chains, bearing significant consequences for ecosystems, the availability of water, energy, and food, and the continuity of large-scale freight transport. Even with a very limited global warming scenario of 0.5°C, extreme weather events such as extreme heat and droughts, heavy rainfall and floods, and extreme storms are projected to intensify over the coming decades.[72] These weather events pose severe impacts to ecosystems, reducing biodiversity, flood regulation, and soil quality.[73] As elaborated on later, water and food security are particularly vulnerable to these effects as agricultural outputs drop and critical water supplies are disrupted.[74] Other critical services, such as the energy infrastructure, are also increasingly exposed to extreme weather events, increasing the risk of extensive damages and blackouts.[75] Finally, extreme weather events are making global supply chains and corridors more volatile and unreliable, resulting in harmful impacts on transport efficiency and increased financial losses in large-scale freight transport.[76] Reducing the impact of extreme weather events, therefore, requires a range of climate adaptation strategies to increase resilience across critical sectors, including food, water, energy, and transport.

Financial systems will have to adapt to the financial needs of global climate adaptation and the risks posed by climate change impacts. As green banking assets are expected to generate $150 billion in annual net interest income by 2040,[77] climate adaptation may increasingly present itself as a viable sector for private investments. According to UNEP, private financing could profitably fulfil $50 billion of annual climate adaptation investment needs,[78] representing an estimate 13-16% of annual financing demand. However, climate change-associated risks pose significant barriers to private investments, for example through the impact of extreme weather events.[79] In this context, insurance companies are uniquely positioned to enable climate resilient financing through novel risk management services such as insurance-linked securities and parametric insurances. [80] As the effects of climate change intensify, unlocking private investments for climate adaptation strategies will become increasingly critical to build climate resilience worldwide.

72 S. I. Seneviratne et al., 'Chapter 11: Weather and Climate Extreme Events in a Changing Climate', in Climate Change 2021: The Physical Science Basis. Contribution of Working GroupI to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change, by V. Masson-Delmote et al. (Cambridge University Press, 2021), 1517–20, https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_Chapter11.pdf#page=5.06.

73 H. Q. Han et al., 'IMPACT OF EXTREME WEATHER EVENTS ON ECOSYSTEM SERVICES', Applied Ecology and Environmental Research 22, no. 4 (2024): 3583.

74 Rose Daphnee Tchonkouang et al., 'Assessing the Vulnerability of Food Supply Chains to Climate Change-Induced Disruptions', Science of The Total Environment 920 (October 2024): 30, https://doi.org/10.1016/j.scitotenv.2024.171047; Michelle E. Miro et al., Assessing Risk to the National Critical Functions as a Result of Climate Change, research (HSOAC, 2022), 32–33, https://www.rand.org/pubs/research_reports/RRA1645-7.html.

75 Julian M. Stürmer et al., The Risk of Cascading Failures in Electrical Grids Triggered by Extreme Weather Events (2021), 1, https://doi.org/10.48550/arXiv.2107.00829.

76 Dimos Touloumidis et al., 'Weather-Related Disruptions in Transportation and Logistics: A Systematic Literature Review and a Policy Implementation Roadmap', Logistics 9, no. 1 (2025): 9–19, 1, https://doi.org/10.3390/logistics9010032.

77 Sek-loong Tan et al., 'Economic Growth Opportunities in a Greening World', BCG Global, 16 January 2025, https://www.bcg.com/publications/2025/economic-growth-opportunities-greening-world.

78 Programme, Adaptation Gap Report 2025.

79 'Climate Change Creates Financial Risks. Investors Need to Know What Those Are.', Brookings, n.d., accessed 7 June 2025, https://www.brookings.edu/articles/climate-change-creates-financial-risks-investors-need-to-know-what-those-are/.

80 Liam Phelan et al., 'Insurance and Climate Change', in Routledge International Handbook of Green Criminology, 2nd edn (Routledge, 2020); Morten Broberg, 'Parametric Loss and Damage Insurance Schemes as a Means to Enhance Climate Change Resilience in Developing Countries', Climate Policy 20, no. 6 (2020): 693–703, https://doi.org/10.1080/14693062.2019.1641461.

3.2. The New Economics of Climate Resilience: Perpetuating Inequalities? (2050-2100)

Climate-resilient economies are essential to meet the increasingly existential demands of global climate adaptation and mitigation.[81] These economies will emerge in those countries where climate policy, innovation and public support converge. They will not be evenly distributed – some will lead, others will lag – but a shift towards climate-sensitive economic planning will reshape how nations define growth, security and competitiveness. Climate-resilient economies will compete on their ability to adapt, not just grow. Regions and countries that will likely lead in this regard include the EU (Nordic countries, the Netherlands), China, Japan, and South Korea. Others may operate at a sub-national level (United States).[82] To enable the world's green transition, massive investments, reaching a cumulative $275 trillion by 2050[83], will have to be made in climate-related adaptation measures, disruptive technologies and circularity.[84] As the fiscal means for climate investments remain concentrated in established economies, regional imbalances and inequalities between the Global North and South may persist.[85]

Climate-resilient economies will compete on their ability to adapt, not just grow.

While adapting their economic models, countries will have to decide whether sustained economic growth can be reconciled with limiting global warming to a maximum of 2°C by the end of the century.[86] So-called green growth models suggest that ever increasing efficiencies and innovations will enable economic growth to be decoupled from carbon emissions, achieving sustainability and adaptation goals while sustaining existing welfare levels.[87] Many scholars are sceptic, however, suggesting it to be impossible to achieve sustainability without drastically reducing the resource and energy use inherent to economic growth. In a 'post-growth' world, they argue, economies and societies will have to deprioritise GDP growth, seeking new sources of non-material prosperity, implementing circular resource flows and establishing redistributive economic institutions.[88] As established economies are decarbonising existing industries towards either of these futures, the Global South faces the dual challenge of accommodating massive demographic expansion while improving welfare and sustainability over the coming decades.[89] It remains a fundamental question whether either of these economic models is fit to resolve this challenge facing the Global South.

81 Tan et al., 'Economic Growth Opportunities in a Greening World'; Vera Songwe et al., Finance for Climate Action - Scaling up Investment for Climate and Development (Grantham Research Institute on Climate Change and the Environment, London School of Economics and Political Science, 2022), 5, https://www.lse.ac.uk/granthaminstitute/wp-content/uploads/2022/11/IHLEG-Finance-for-Climate-Action-1.pdf.

82 James Meadowcroft and Daniel Rosenbloom, 'Governing the Net-Zero Transition: Strategy, Policy, and Politics', Proceedings of the National Academy of Sciences 120, no. 47 (2023): e2207727120, https://doi.org/10.1073/pnas.2207727120.

83 Mekala Krishnan et al., The Net-Zero Transition (McKinsey Global Institute, 2022).

84 Mingyue Zhang et al., 'Achieving Carbon-Neutral Economies through Circular Economy, Digitalization, and Energy Transition', Scientific Reports 15, no. 1 (2025): 13779, https://doi.org/10.1038/s41598-025-97810-w.

85 International Investment in Climate Change Mitigation and Adaptation - Trends and Policy Developments (United Nations, 2022), 1, https://unctad.org/system/files/official-document/diaeinf2022d2_en.pdf.

86 Jason Hickel and Giorgos Kallis, 'Is Green Growth Possible?', New Political Economy 25, no. 4 (2020): 469–86, https://doi.org/10.1080/13563467.2019.1598964.

87 Jochen Hinkel et al., 'Transformative Narratives for Climate Action', Climatic Change 160, no. 4 (2020): 495–506, https://doi.org/10.1007/s10584-020-02761-y.

88 Giorgos Kallis et al., 'Research On Degrowth', Annual Review of Environment and Resources 43, no. Volume 43, 2018 (2018): 291–316, https://doi.org/10.1146/annurev-environ-102017-025941; Fiona Dukelow and Mary P. Murphy, 'Building the Future from the Present: Imagining Post-Growth, Post-Productivist Ecosocial Policy', Journal of Social Policy 51, no. 3 (2022): 504–18, https://doi.org/10.1017/S0047279422000150.

89 Pradeepta Sethi et al., 'Globalization, Financial Development and Economic Growth: Perils on the Environmental Sustainability of an Emerging Economy', Journal of Policy Modeling 42, no. 3 (2020): 520–35, https://doi.org/10.1016/j.jpolmod.2020.01.007.

Agricultural markets and food commodity pricing are changing as rising temperatures cause environmental degradation, soil erosion, and extreme weather events.

The fifth industrial revolution will shape future societies and labour markets, intersecting with climate-induced inequalities between countries. While AI-based innovations are the hallmark of the fourth industrial revolution, the integration of humans, artificial intelligence and robotics is theorised to constitute the fifth industrial revolution unfolding by mid-century.[90] This revolution is expected to continue reducing demand for practical-skilled labour in favour of knowledge-intensive work, as technological and soft skills become increasingly important for enabling the integration and cooperation between humans and machines.[91] This transition requires both reskilling and upskilling workers to enable their adaptation to evolving job markets and to ensure societies can reap the benefits of the fifth industrial revolution.[92] Socioeconomic differences between countries, however, create unequal capacities between states for workforce development, potentially deepening existing economic inequalities between the Global North and South.[93] These inequalities interact with and further amplify the effects of unequally distributed climate risks and adaptive capacity between developed and developing countries. [94]

Agricultural markets and food commodity pricing are changing as rising temperatures cause environmental degradation, soil erosion, and extreme weather events.[95] A 1°C increase in global mean temperature is projected to reduce global yields of major crops by 3.1-7.4%.[96] More recent studies put these estimates on 6.1% with a 2.38°C rise in temperature, rising to 8.2% per 1°C after reaching this threshold.[97] Moreover, as temperature, precipitation, and extreme weather events become increasingly volatile, yield variability will significantly increase, particularly across North America, Europe, Central Asia and China.[98] Crop nutritional value too will fall as soil erosion negatively impacts biochemical cycles and reduces

90 Rushan Ziatdinov et al., 'The Fifth Industrial Revolution as a Transformative Step towards Society 5.0', Societies 14, no. 2 (2024): 2, https://doi.org/10.3390/soc14020019.

91 Michaela Poláková et al., 'Soft Skills and Their Importance in the Labour Market under the Conditions of Industry 5.0', Heliyon 9, no. 8 (2023): e18670, https://doi.org/10.1016/j.heliyon.2023.e18670.

92 Ling Li, 'Reskilling and Upskilling the Future-Ready Workforce for Industry 4.0 and Beyond', Information Systems Frontiers 26 (2024): 1697–712, https://doi.org/10.1007/s10796-022-10308-y; 'Employment and Social Developments in Europe (ESDE) 2023', European Commission, https://employment-social-affairs.ec.europa.eu/employment-and-social-developments-europe-2023_en#:~:text=In%20the%20light%20of%20the%20importance%20of%20skills,shortages%20and%20changing%20skills%20needs%20in%20the%20EU.

93 Yannick Griep, 'Climate Change as a Catalyst for Economic Inequality: The Failure of Workplace Learning in the Global South', Industrial and Organizational Psychology 18, no. 1 (2025): 115, https://doi.org/10.1017/iop.2024.62.

94 Philip Kofi Adom, 'The Socioeconomic Impact of Climate Change in Developing Countries over the next Decades: A Literature Survey', Heliyon 10, no. 15 (2024), https://doi.org/10.1016/j.heliyon.2024.e35134; Paul Chinowsky et al., 'Climate Change: Comparative Impact on Developing and Developed Countries', Engineering Project Organization Journal 1, no. 1 (2011): 67–80, https://doi.org/10.1080/21573727.2010.549608; Griep, 'Climate Change as a Catalyst for Economic Inequality', 115.

95 Ahmad Hamidov et al., 'Impacts of Climate Change Adaptation Options on Soil Functions: A Review of European Case studies', Land Degradation & Development 29, no. 8 (2018): 2378–79, https://doi.org/10.1002/ldr.3006; Joris P. C. Eekhout and Joris de Vente, 'Global Impact of Climate Change on Soil Erosion and Potential for Adaptation through Soil Conservation', Earth-Science Reviews 226 (March 2022): 1, https://doi.org/10.1016/j.earscirev.2022.103921; OECD/FAO, OECD-FAO Agricultural Outlook 2023-2032 (OECD, 2023), 56, https://www.oecd.org/en/publications/oecd-fao-agricultural-outlook-2023-2032_08801ab7-en/full-report/agricultural-and-food-markets-trends-and-prospects_c9361e2a.html; Taufiq Nawaz et al., 'Impact of Elevated CO2 and Temperature on Overall Agricultural Productivity', in Challenges and Solutions of Climate Impact on Agriculture, ed. Shah Fahad et al. (Academic Press, 2025), https://doi.org/10.1016/B978-0-443-23707-2.00007-6.

96 Chuang Zhao et al., 'Temperature Increase Reduces Global Yields of Major Crops in Four Independent Estimates', Proceedings of the National Academy of Sciences 114, no. 35 (2017): 9326–31, https://doi.org/10.1073/pnas.1701762114.

97 Bao-Linh Tran et al., 'Climate Change Impacts on Crop Yields across Temperature Rise Thresholds and Climate Zones', Scientific Reports 15, no. 1 (2025): 23424, https://doi.org/10.1038/s41598-025-07405-8.

98 Sebastian Ostberg et al., 'Changes in Crop Yields and Their Variability at Different Levels of Global Warming', Earth System Dynamics 9, no. 2 (2018): 492, https://doi.org/10.5194/esd-9-479-2018.

the soil's capacity to hold water and nutrients.[99] As a result, it is projected that, depending on socio-economic developments, climate change could increase the number of undernourished people with 8-80 million people by 2050.[100] Additionally, reduced and variable crop yields are expected to drive up crop prices and increase price volatility, with rice and wheat prices projected to increase with 34% to 61% by 2050.[101] Climate adaptation strategies offer opportunities to reduce the impacts of climate change on food production, including crop diversification and rotation, improved water and soil management, investments in weather forecasting, and early warning systems.[102]

99 Eekhout and de Vente, 'Global Impact of Climate Change on Soil Erosion and Potential for Adaptation through Soil Conservation', 1.

100 Cheikh Mbow and Cynthia Rosenzweig, Chapter 5 : Food Security — Special Report on Climate Change and Land (2019), 462, https://doi.org/10.1017/9781009157988.007.

101 Huong Nguyen et al., 'Factors Affecting Crop Prices in the Context of Climate Change—A Review', Agriculture 14, no. 1 (2024): 6–7, 1, https://doi.org/10.3390/agriculture14010135.

102 Elena Grigorieva et al., 'Adaptation of Agriculture to Climate Change: A Scoping Review', Climate 11, no. 10 (2023): 6–7, 10, https://doi.org/10.3390/cli11100202.

4. Environmental and Societal Developments

Climate change will amplify the complex, reinforcing dynamic between environmental change and societal developments, influencing patterns of governance, social stability and conflict risks in vulnerable regions. As two thirds of the global population will reside in cities by 2050, urban resilience and climate adaptation will prove crucial to mitigate disaster risks and ensure liveability and human well-being in urban areas. Fragile regions unable to adapt to climate change, especially those disproportionately affected by its impacts, will face the destabilising effects of resource and land scarcity. In these countries, climate change functions as a threat multiplier leading to increased risks of intercommunal and transboundary tensions and conflicts. Throughout the century, biodiversity loss compounds these pressures, as ecological stability and human well-being are threatened by mass extinctions and disruptions of ecosystems.

Climate resilience becomes a key determinant of political legitimacy, sovereignty, and international influence.

These destabilising effects of climate change are projected to give rise to internal and cross-border migration flows that could reach 87-133 million people by 2060, with sub-Saharan Africa, South- and East Asia bearing the heaviest displacement burdens.[103] While climate migration offers an effective coping strategy for individuals, it generates pressures on host communities and complicates international relations, particularly as the Global North faces rising populist resistance to incoming migration flows. In fragile and climate-vulnerable states, environmental and societal pressures may overwhelm governance capacities, leading to growing dependence on external actors to perform core functions. As such, climate resilience becomes a key determinant of political legitimacy, sovereignty, and international influence.

The complex interplay between environmental degradation, human well-being and societal stability is further explored in the remainder of this chapter. If not managed effectively, climate change will prove to be a destabilising force in fragile and climate-vulnerable regions, both in the coming decades and, as its impacts intensify, in the second half of the 21st century.

4.1. Climate Impacts on Social Stability (now-2050)

Rapid urbanisation is projected to increase the percentage of the global population living in cities from one third in 1950, to nearly 70% in 2050.[104] Countries in Africa and Asia, in particular, will continue to experience high levels of urban growth in the coming decades.[105]

[103] Cristina Cattaneo et al., 'Climate Variability and Worldwide Migration: Empirical Evidence and Projections', IMF Working Papers, IMF Working Papers 2024, no. 058 (2024), https://doi.org/10.5089/9798400270772.001.

[104] Xueqin Li et al., 'The Impacts of Urbanisation and Climate Change on the Urban Thermal Environment in Africa', Climate 10, no. 11 (2022): 11, https://doi.org/10.3390/cli10110164.

[105] '68% of the world population projected to live in urban areas by 2050, says UN', United Nations, United Nations, 2018, https://www.un.org/uk/desa/68-world-population-projected-live-urban-areas-2050-says-un; Brandon Marc Finn and Patrick Brandful Cobbinah, 'African Urbanisation at the Confluence of Informality and Climate Change', Urban Studies 60, no. 3 (2023): 405–24, https://doi.org/10.1177/00420980221098946.

In contexts where this urbanisation is unplanned and rapid, the impacts of climate change can pose significant challenges to urban resilience and liveability. A lack of vegetation and high building density, for example, are major contributors to the creation of urban heat islands.[106] As a result, cities may experience greater exposure to extreme heat, leading to increased demand for water and energy, poorer air quality, higher pollution levels, and greater health risks.[107] Rapid urbanisation can also increase pressure on public service infrastructure. City growth can, for example, outpace existing capacities of urban water systems, drainage networks, and treatment plants. Access to public infrastructure is particularly challenging in areas where urban growth is characterised by and closely tied to informal settlements and movements.[108] Lastly, rapid and unplanned urbanisation increases the vulnerability to disaster risk, with natural and human-induced hazards mutually reinforcing each other.[109] Urbanisation amplifies disaster risks through increased density of infrastructure facilities and buildings, lack of coordination between actors, and environmental degradation.[110]

While urbanisation can increase climate vulnerability in low-income countries, it also offers opportunities in transitioning and emerging economies to strengthen their adaptive capacity to climate risks. For example, economic growth and efficiency gains can be used to improve disaster risk management.[111] Managing urban growth, including the use of climate adaptation measures, will be crucial to untap these opportunities and to avert the intersecting risks to liveability posed by rapid urbanisation and climate change.

Climate-induced conflict risks are likely to grow as the disproportionate impacts of climate change affect fragile and conflict-affected states. Due to their geographical location and social-economic dependence on agriculture, these countries are more sensitive to climate-induced GDP losses and heightened food insecurity.[112] In such contexts, natural resource scarcity may act as both a threat multiplier and a stressor, exacerbating pre-existing socioeconomic and political tensions. The impacts of climate change, violence and social vulnerability can reinforce each other, creating a vicious circle of declining societal stability.[113] Climate change-related impacts, for example, particularly affect agriculture-based livelihoods. As drought and desertification increasingly threaten rural communities, the risk of recruitment into armed groups is found to rise significantly in affected areas.[114] Environmental factors

106 Yuan Yuan et al., 'Surface Urban Heat Island Effects Intensify More Rapidly in Lower Income Countries', Npj Urban Sustainability 5, no. 1 (2025): 11, https://doi.org/10.1038/s42949-025-00198-9.

107 Awais Piracha and Muhammad Tariq Chaudhary, 'Urban Air Pollution, Urban Heat Island and Human Health: A Review of the Literature', Sustainability 14, no. 15 (2022): 2, 15, https://doi.org/10.3390/su14159234; Glenn Kong et al., 'Modelling Urban Heat Island Effects: A Global Analysis of 216 Cities Using Machine Learning Techniques', Computational Urban Science 5 (2025): 1, https://doi.org/10.1007/s43762-025-00178-w.

108 Patrick Brandful Cobbinah and Brandon Marc Finn, 'Planning and Climate Change in African Cities: Informal Urbanization and "Just" Urban Transformations', Journal of Planning Literature 38, no. 3 (2023): 361–79, https://doi.org/10.1177/08854122221128762.

109 Matthias Garschagen and Patricia Romero-Lankao, 'Exploring the Relationships between Urbanization Trends and Climate Change Vulnerability', Climatic Change 133, no. 1 (2015): 37–52, https://doi.org/10.1007/s10584-013-0812-6; Omar Dario Cardona et al., 'Determinants of Risk: Exposure and Vulnerability', in Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation: Special Report of the Intergovernmental Panel on Climate Change (Cambridge University Press, 2012), https://doi.org/10.1017/CBO9781139177245.005.

110 Cardona et al., 'Determinants of Risk', 78.

111 Garschagen and Romero-Lankao, 'Exploring the Relationships between Urbanization Trends and Climate Change Vulnerability'.

112 Laura Jaramillo et al., 'Climate Challenges in Fragile and Conflict-Affected States', Staff Climate Notes, Staff Climate Notes 2023, no. 001 (2023), https://doi.org/10.5089/9798400252082.066.A001.

113 Halvard Buhaug and Nina von Uexkull, 'Vicious Circles: Violence, Vulnerability, and Climate Change', Annual Review of Environment and Resources 46, no. Volume 46, 2021 (2021): 545–68, https://doi.org/10.1146/annurev-environ-012220-014708.

114 Leanna Augsten et al., 'The Human Dimensions of the Climate Risk and Armed Conflict Nexus: A Review Article', Regional Environmental Change 22, no. 2 (2022): 42, https://doi.org/10.1007/s10113-022-01888-1.

such as floods and extreme heat may also contribute to increased internal and transboundary migration. Concentration of populations in migration hotpots may put additional pressure on available water and food resources, potentially sparking tensions and conflict between displaced and hosting communities.[115] Lastly, as climate change amplifies resource and land scarcity, it fuels potentially violent disputes over access to land and water – both within and between countries.[116] Therefore, especially in fragile and conflict-affected states, it is essential to invest in adequate climate adaptation measures to reduce climate-induced conflict risks that threaten stability and peace.

4.2. Climate Displacement, Environmental Degradation and Sovereign Decline (2050-2100)

As climate change amplifies resource and land scarcity, it fuels potentially violent disputes over access to land and water – both within and between countries.

Worldwide migration flows are projected to reach 87 to 133 million by 2060, as climate change becomes both a direct and indirect contributor to internal and cross-border migration.[117] Especially sub-Saharan Africa, South- and East Asia are expected to be faced with major numbers of internally displaced people.[118] These migration flows are driven by increasing temperatures, rising sea levels, reduced water availability, and extreme weather events as key drivers of human mobility, for example by undermining food, water, energy, and economic security.[119] While climate-induced migration can cause human suffering and challenge the capacities of hosting communities, it is simultaneously an effective coping strategy for individuals in response to climate-related stresses. As such, it can offer opportunities for migrants to improve livelihoods and gain greater access to public services such as healthcare and education.[120] To manage climate-related migration flows, it will be crucial to invest in climate adaptation measures, integrate climate migration into development policy, and strengthen research efforts.[121]

Though most climate-induced displacement is expected to occur within national borders, climate migration will also become a key issue in international relations. In the Global South, states already experiencing conflict are likely to see more emigration, placing pressure on the fragile state structures of neighbouring countries that serve as transit or destination hubs.[122] In the Global North, incoming migration flows may be met with public scepticism and rising

115 Linlang He et al., 'Interventions Addressing Conflict in Communities Hosting Climate-Influenced Migrants: Literature Review', Environment and Security 2, no. 1 (2024): 145–74, https://doi.org/10.1177/27538796231207919.

116 Kerstin Unfried et al., 'Water Scarcity and Social Conflict', Journal of Environmental Economics and Management 113 (May 2022): 102633, https://doi.org/10.1016/j.jeem.2022.102633; He et al., 'Interventions Addressing Conflict in Communities Hosting Climate-Influenced Migrants'.

117 Cattaneo et al., 'Climate Variability and Worldwide Migration', 15.

118 'Groundswell Report', World Bank, September 2021, https://www.worldbank.org/en/news/press-release/2021/09/13/climate-change-could-force-216-million-people-to-migrate-within-their-own-countries-by-2050.

119 Maria McAuliffe and Linda Adhiambo Oucho, World Migration Report 2024 (Internationl Organization for Migration (IOM), 2024), 200, https://publications.iom.int/books/world-migration-report-2024; Kanta Kumari Rigaud et al., Groundswell: Preparing for Internal Climate Migration (World Bank, 2018), 25, https://hdl.handle.net/10986/29461.

120 Rajan Chandra Ghosh and Caroline Orchiston, 'A Systematic Review of Climate Migration Research: Gaps in Existing Literature', SN Social Sciences 2, no. 5 (2022): 47, https://doi.org/10.1007/s43545-022-00341-8.

121 Rigaud et al., Groundswell.

122 Benjamin Freedman, 'Getting Ahead of the Middle East's Climate Refugee Conundrum', Middle East Institute, 2023, https://www.mei.edu/publications/getting-ahead-middle-easts-climate-refugee-conundrum.

populist nationalism.[123] If such political and societal views persist, climate migrants could remain unrecognised and unprotected under international law, creating a protection gap that leaves millions of people vulnerable to climate-related risks.[124]

Biodiversity loss creates challenges for long-term ecological stability and human well-being. Rising temperatures, extreme weather events, flooding, and droughts are altering habitats, spreading diseases, degrading soil quality and contributing to ocean acidification.[125] As a result, many species are either expected to rapidly migrate or face extinction in the second half of this century.[126] By 2100, 12.6% of plant species are projected to be at risk of extinction worldwide, reaching 9.4% and 17.7% for invertebrates and vertebrates respectively.[127] The risk of biodiversity loss does not only impact ecological stability but has profound impacts on human well-being. Food insecurity, for example, may be amplified by decreasing crop productivity, increased prevalence of pests, and declining numbers of pollinators.[128] Additionally, public health is at risk as the likelihood of zoonotic disease transmissions rises and medicinal plant species used in traditional and industrial medicine are at risks of extinction.[129] The impacts of biodiversity loss, thus, pose a unique set of challenges for climate adaptation strategies.

Climate migrants could remain unrecognised and unprotected under international law, creating a protection gap that leaves millions of people vulnerable to climate-related risks.

Environmental breakdown may transform political authority in fragile states that are disproportionately impacted by climate change. As climate impacts accelerate into the second half of the 21st century, environmental stress will increasingly overwhelm fragile states' ability to govern effectively.[130] In regions where public institutions remain weak, these pressures drive internal displacement, erode food and water systems, and exacerbate pre-existing socio-political tensions.[131] These disproportionate impacts intersect with preexisting inequalities between the Global North and South, as those most vulnerable to climate change have least access to the financial, technological, and institutional means to implement adaptation

123 Fran Woodworth, 'Exclusion of Climate Migrants from the Global Compact on Refugees', Geopolitics 29, no. 1 (2024): 132, https://doi.org/10.1080/14650045.2023.2225242.

124 Samreen Tahir and Waleed Tahir, 'Climate-Related Migration and Displacement: Legal Protections for 'Climate Refugees', Mayo Communication Journal 1, no. 2 (2024): 2.

125 'How Does Climate Change Affect Biodiversity?', The Royal Society, accessed 26 May 2025, https://royalsociety.org/news-resources/projects/biodiversity/climate-change-and-biodiversity/; Russell Taylor, 'Biodiversity Loss and Climate Change: Interdependent Global Challenges', UK Parliament House of Lords Library, 1 September 2025, 4, 6–7, https://lordslibrary.parliament.uk/biodiversity-loss-and-climate-change-interdependent-global-challenges/; 'UN Report: Nature's Dangerous Decline "Unprecedented"; Species Extinction Rates "Accelerating"', United Nations Sustainable Development, 5 June 2019, https://www.un.org/sustainabledevelopment/blog/2019/05/nature-decline-unprecedented-report/.

126 Melese Genete Muluneh, 'Impact of Climate Change on Biodiversity and Food Security: A Global Perspective—a Review Article', Agriculture & Food Security 10, no. 36 (2021): 6–7, https://doi.org/10.1186/s40066-021-00318-5.

127 Muluneh, 'Impact of Climate Change on Biodiversity and Food Security', 6–7.

128 Muluneh, 'Impact of Climate Change on Biodiversity and Food Security', 5; K. R. Shivanna, 'Climate Change and Its Impact on Biodiversity and Human Welfare', Proceedings of the Indian National Science Academy 88 (2022): 163, 164, https://doi.org/10.1007/s43538-022-00073-6; Dilys Roe, 'Biodiversity Loss—More than an Environmental Emergency', The Lancet Planetary Health 3, no. 7 (2019): e288, https://doi.org/10.1016/S2542-5196(19)30113-5.

129 Felicia Keesing and Richard S. Ostfeld, 'Impacts of Biodiversity and Biodiversity Loss on Zoonotic Diseases', Proceedings of the National Academy of Sciences 118, no. 17 (2021): 6–7, https://doi.org/10.1073/pnas.2023540118; Mihir Halder and Sumita Jha, 'The Current Status of Population Extinction and Biodiversity Crisis of Medicinal Plants', in Medicinal Plants: Biodiversity, Biotechnology and Conservation, ed. Sumita Jha and Mihir Halder (Springer Nature, 2023), https://doi.org/10.1007/978-981-19-9936-9_1; James Ashworth, Climate Change Will Affect Diseases in Widespread and Varied Ways, 12 December 2025, https://www.nhm.ac.uk/discover/news/2025/december/climate-change-will-affect-diseases-widespread-varied-ways.html.

130 Climate Change 2022: Impacts, Adaptation and Vulnerability., with Hans-Otto Pörtner et al. (IPCC, 2022).

131 Jaramillo et al., 'Climate Challenges in Fragile and Conflict-Affected States'.

strategies.[132] Within states lacking adaptive capacity, the impacts of low resilience will fall hardest on disadvantaged groups already facing socio-economic inequalities. [133]

Without sufficient adaptive capacity, these states will become increasingly reliant on external actors, ranging from powerful countries to regional blocs and multinational firms, to manage essential governance functions.[134] This growing adaptation dependence will challenge the traditional meaning of sovereignty. Rather than being fully autonomous, some states may face increased reliance on external actors, raising the possibility of de-facto climate protectorate-like arrangements.[135] The result will be a world of stratified sovereignty: climate resilient states will consolidate control, while others experience a dilution of authority in line with their vulnerability.[136] Over time, the ability to manage environmental risk will become a key criterion for political legitimacy and international influence.

Some states may face increased reliance on external actors, raising the possibility of de-facto climate protectorate-like arrangements.

132 Alexander Schulan and Jan-Christoph Heilinger, 'Three Injustices of Adaptation Finance - A Relational Egalitarian Analysis', Journal of Agricultural and Environmental Ethics 37 (2024): 1–18, https://doi.org/10.1007/s10806-024-09932-2.

133 Renee Zahnow et al., 'Climate Change Inequalities: A Systematic Review of Disparities in Access to Mitigation and Adaptation Measures', Environmental Science & Policy 165 (March 2025): 2, https://doi.org/10.1016/j.envsci.2025.104021; 'Towards "Just Resilience": Leaving No One behind When Adapting to Climate Change', European Environment Agency, 29 June 2022, https://www.eea.europa.eu/publications/just-resilience-leaving-no-one-behind/towards-just-resilience-leaving-no.

134 Stephen D. Krasner and Thomas Risse, 'External Actors, State-Building, and Service Provision in Areas of Limited Statehood', in Domestic Politics and Norm Diffusion in International Relations, ed. Thomas Risse (2014), https://library.oapen.org/bitstream/handle/20.500.12657/50470/1/9781317226697.pdf#page=208.

135 Frank Biermann and Ingrid Boas, 'Preparing for a Warmer World: Towards a Global Governance System to Protect Climate Refugees', Global Environmental Politics 10, no. 1 (2010): 60–88, https://doi.org/10.1162/glep.2010.10.1.60.

136 Jan Aart Scholte, 'Beyond Institutionalism: Toward a Transformed Global Governance Theory', International Theory 13, no. 1 (2021): 179–91, https://doi.org/10.1017/S1752971920000421.

5. Conclusion

International relations in the 21st century will increasingly be shaped by those actors that are willing to adapt to, act on, and bear the costs of managing and mitigating the impacts of climate change. Countries will compete for access to scarce resources and for control over the technologies critical to the clean energy transition. Most nations will face difficult economic choices and rely on technological breakthroughs elsewhere to support their adaptation efforts. This means there will be both winners and losers – dynamics that will define inter-state competition for decades to come. The ability to adapt swiftly and strategically to climate change will become a defining superpower in the emerging global order.

The ability to adapt swiftly and strategically to climate change will become a defining superpower in the emerging global order.

Against this geopolitical backdrop, the success of global climate adaptation will be determined by technological advancements and equal access to adaptation measures and financing. While established economies have the fiscal means and technological expertise to enable a green transition, developing countries face the dual challenge of accommodating massive demographic growth while improving welfare and sustainability over the coming decades. Their ability to adapt to the escalating risks of climate change will depend on the persistence of structural inequalities between the Global North and South. In fragile states disproportionately at risk of climate impacts, limited adaptive capacity will amplify socio-political tensions and societal instability, with spillover effects that contribute to broader regional and global insecurity.

In the coming decades, global action on climate adaptation will prove crucial to mitigate the economic and societal impacts of climate change. Although societies and individuals around the world may face major climate-related challenges, adaptation strategies can be implemented to reinforce positive feedback loops and to mitigate or dampen the effect of identified interactions. Achieving this will require an integrated global approach that accounts for the multifaceted and widespread nature of climate impacts until the end of this century. This will also require more effective and decisive global governance, including multilateral reform and better coordination between universal institutions and minilateral, implementation-focused coalitions. Despite an increasingly fragmented international order, climate adaptation may emerge as a shared priority, creating opportunities for renewed cooperation and convergence between states.

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